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RECENT EXCAVATIONS IN THE ROMAN FORUM.

THE Forum Romanum Magnum, from which the destinies of the ancient world were decided for many centuries, is without doubt the most interesting spot in Rome, if not in all Southern Europe, and the recent excavations which have added so much to our knowledge of the early history of Rome have been most gratifying in their results. In the most ancient times the Capitoline and Palatine Hills were separated by a deep and marshy valley. At that remote period in the legendary history of Rome when the Palatine and Capitoline Hills were still occupied by separate fortified villages, inhabited by hostile tribes, the intermediate valley which afterward became the chief center of Roman life was a marshy morass which, specially in the rainy seasons, was interspersed with large pools of stagnant water. At times, however, the ground became sufficiently hard to form a battlefield, and here, according to tradition, were held the heroic fights between the Sabines of the Capitol and the Latins of

THE LAPIS NIGER, THE REPUTED BURIAL PLACE OF ROMULUS.

RUINS OF THE AEMILIAN BASILICA.

THE ROMAN FORUM—ARCH OF SEPTIMIUS SEVERUS, SHOWING THE NEW EXCAVATIONS.

Roma Quadrata. Tarquinius Priscus is accredited with the construction of the great sewer which was the first step toward the improvements which were followed by the erection of superb buildings. For centuries there was no other public place, and it served for every use. In the early morning all kinds of goods were sold there, throughout the day it was a court of justice, and in the evening people took their walks there.

As time went on, public places multiplied, and there were special markets for the sale of cattle, vegetables and fish; but the old Forum of Romulus still retained its prestige. The Forum is of such a small size that it is very extraordinary that the last years of the nineteenth century were permitted to witness the uncovering of many important remains. These may be divided as follows: First, the base of the column set up where Cæsar's body was burned; second, the "black stone," the "Lapis Niger" of the classics, which is supposed to mark the tomb of Romulus; third, the Aemilian Basilica; and, fourth, the excavations of the Regia, which are so well described by Signor Boni in SCIENTIFIC AMERICAN SUPPLEMENT, No. 1273.

The "Black Stone" was found near the arch of Septimus Severus, as shown in our large engraving; behind is the Capitol with the Tabularium at its base. At the extreme right is the Mamertine Prison, made out of an old quarry. At the left is the Temple of Saturn. The Aemilian Basilica on the northern side of the Forum is on the right of the arch, and is further down the Forum toward the Colosseum.

We will refer to the excavations in more detail. The base of the column set up to mark the spot of the funeral pyre of Julius Cæsar was found. An altar and a column of Numidian marble served to mark the locality. The illicit worship of Cæsar was stopped, but in 42 B. C. the Triumvirs decided to erect a temple, and it was dedicated in A. D. 29. The temple was raised on a platform, as was the lowest part of the Forum. On the edge of the podium was a hemicycle, or semicircular tribune. The space between the late tufa wall and the hemicycle was cleared away recently, and there resting on the pavement was the base of the column. Here the body of Cæsar was reduced to ashes, and here Antony made his famous oration. Only the core of the base is left.

The "Black Stone" is about as interesting; it is referred to by generations of classical writers. It is a pavement 12 feet square, partly inclosed by a low wall of travertine slabs fixed in a stone socket or trough—proof of the care with which it was guarded. When the road that now runs through the arch of Septimius Severus was built, large slabs were raised like a solid fence to protect the black stones. The blocks of the pavement are of black marble streaked with white. Some of the archæologists claim the Lapis Niger marked the spot where Curtius leaped into the gulf. The bases of sculptured lions were found below the stone, as well as a mutilated stele with archaic Latin characters which have never been satisfactorily deciphered. The inscription has been found, however, in a general way to deal with the making of sacrifices. A layer of ashes and votive objects were also found.

Mr. Phillips, an Englishman, gave the site of the Aemilian Basilica to the Italian government, in order that it might be excavated. In 54 B. C. L. Aemilius Paullus bought private property on the north side of the Forum and built the superb Basilica which bears his name. It was constructed to give more room to the Forum, and cost its donor about $2,400,000. The original plan was like most buildings of this kind, a long colonnade with rooms behind; the superstructure has been destroyed. The colonnade was built of white marble shafts resting on travertine bases. Charming bits of pavement were found, as well as a richly decorated metope. The uncovering of the ruins shows that the columns of S. Paolo without the walls were not derived from this source.

ARCHAEOLOGY IN THE PAST CENTURY.*

By Prof. W. M. FLINDERS PETRIE, D.C.L., LL.D. of University College, London.

WE now purpose to review the growth of archæology in contact with geology, where it concerns man as the last of the links of life on the globe; and then to notice the archæology of each country in turn, as it leads on to the times of historical record, and so passes down to modern times.

The great new force which thrust itself in to divide and decide on such questions is the scientific study of man and his works. Strangely shaped flints had been noticed, but no one had any knowledge of their age. One such when found with the bones of a mammoth was attributed to the Roman age, because no person could have brought elephants into Britain except some Roman general. The argument was excellent and irrefutable until geology found plenty more remains of the mammoth and showed that it was here long before the Romans. It was less than half a century ago that our eyes began to open to the abundant remains of flint-using man. Then a single rude stone weapon was an unexplained curiosity; now an active collector will put together his tens of thousands of specimens, will know exactly where they were found, their relation of age and of purpose, and their bearing on the history of man.

Not only have worked flint implements been found in the river gravels of France and England, where they were first noticed in the middle of this century, but also in most parts of Europe, in Egypt on the high desert, in Somaliland, at the Cape of Good Hope, in India, America and other countries; and the most striking feature is the exact similarity in form wherever they have been found. So precisely do the same types recur, so impossible would it be to say from its form whether a flint had been found in Europe, Asia, or Africa, that it appears as if the art of working had spread from some single center over the rest of the world. This is specially the case with the river gravel flints—the earlier class—usually called Paleolithic. Soon after the general division had been made between polished stone work of the later or Neolithic times, found on the surface, and the rough chipped work of the earlier or Paleolithic times, found in geological deposits, a further subdivision was made by separating the Paleolithic age into that of the river gravels and that of the cave dwellers. The latter has again been divided into three classes by French writers, named from their localities, *Mousterien*, *Solutrien*, *Magdalenien;* and though these classes may be much influenced by locality they probably have some difference of age between them.

And now within the last few years a still earlier kind of workmanship has been recognized in flints found in England on the high hills in Kent. Though at first much disputed, the human origin of the forms is now generally acknowledged, and they show a far ruder ability than even the most massive of the Paleolithic forms. The position also of these flints, in river deposits lying on the highest hills some six-hundred feet above the present rivers, shows that the whole of the valleys has been excavated since they were deposited, and implies a far greater age than any of the gravel beds of the Paleolithic ages.

We, therefore, have passed now at the end of this century to a far wider view of man's history, and classify his earlier ages in Europe thus:

First—Eolithic: Rudest massive flints from deposits 600 feet up.

Second—Paleolithic: Massive flints from gravels 200 feet up and less (Achuleen).

Third—Paleolithic—Cave dwellers: Flints like the preceding and flakes (Mousterien).

Fourth—Paleolithic—Cave dwellers: Flints well worked and finely shaped (Solutrien).

Fifth—Paleolithic—Cave dwellers: Abundant bone working and drawing (Magdalenien).

Sixth—Neolithic: Polished flint working, pastoral and agricultural man.

What time these periods cover nothing yet proves. The date of 4000 B. C. for man's appearance, with which belief our century started, has been pushed back by one discovery after another. Estimates of from 10,000 to 200,000 years have been given from various possible clews. In Egypt an exposure of 7,000 years or more only gives a faint brown tint to flints, lying side by side with Paleolithic flints that are black with age. I incline to think that 100,000 years B. C. for the rise of the second class and 10,000 B. C. for the rise of the sixth class will be a moderate estimate.

Passing now from Paleolithic man of the latest geological times whose works lie under the deposit of ages to Neolithic man of surface history whose polished stone tools lie on the ground, we find also how greatly views have changed. For ages past metal-using man has looked on the beautifully polished or chipped weapons of his forefathers as "thunderbolts" possessing magic powers, and he often mounted the smaller ones to wear as charms. At the beginning of this century well-finished stone weapons were only preserved as curiosities which might belong to some remote age, but without any definite ideas about them. The recognition of long ages of earlier unpolished stone work has now put these more elaborate specimens to a comparatively late period and yet they are probably older than the date to which our forefathers placed the creation of man.

The Neolithic man made pottery, spun and wove linen, constructed enormous earthworks both for defense and for burial, and systematically made his tools of the best material he could obtain by combined labor in mining. The extensive flint mines in chalk districts of England show long-continued labor; and the perfect form and splendid finish of many of the stone weapons show that skilled leisure could be devoted to them, and that æsthetic taste had been developed. The large camps prove that a thorough tribal organization prevailed, though probably confined to small clans.

About the middle of the century a new type of dwelling began to be explored, the lake dwelling; this system of building towns upon piles in lakes had the great advantage of protection from enemies and wild beasts, and a constant supply of food in the fish that could be hooked from the water below. Though such settlements were first found in the Swiss lakes, and explored there by Keller, they have since been found in France, Hungary, Italy, Holland and the British Isles. The earlier settlements of this form belong to the Neolithic age, but only in central Europe. In these earliest lake dwellings weaving was known, and the cultivation of flax, grapes and other fruit and corn; while the usual domestic animals were kept and cattle were yoked to the plow; pottery was abundant, and was often ornamented with geometric patterns. The type of man was roundheaded. Following the Neolithic lake dwellings came those of the Bronze age, and as the bronze objects are similar to those found in other kinds of dwellings we shall notice them in the Bronze age in general. The type of man was longer-headed than in the earlier lake settlement. The domestication of animals shows an advance; the horse was common, and the dog, ox, pig and sheep were greatly improved. Pottery was better made and elaborately decorated, often with strips of tinfoil.

The Bronze age marks a great step in man's history. In many countries the use of copper, hardened by arsenic or oxide, was common for long before the alloy of copper and tin was used. In other countries where the use of metals was imported, copper only appears as a native imitation of the imported bronze. Hence there is a true age of copper in lands where the use of metals has grown. It must by no means be supposed that copper excluded the use of flint; it was not until bronze became common that flint was disused. The existence of a Bronze age was first formulated as distinct from a stone age about seventy years ago; and the existence of a copper age has been much disputed in the last thirty years, but has only been proved clearly ten years ago, in Egypt.

In the eighteenth century the bronze weapons found in England were attributed to the Romans by some writers, though others, with more reason, argued that they were British. In the first year of this century began the comparative study of such weapons with reference to modern savage products. The development of the metal forms from stone prototypes was pointed out in 1816; the tracing out of the succession of forms and the modes of use appeared in 1847. Further study cleared up the details, and within the last twenty years the full knowledge of the Bronze age in other countries has left no question as to the general facts of the sequence of its history. In each type of tool and weapon there appears first a very simple form imitated from the stone implements which were earlier used. Gradually the facilities given by the casting and toughness of the metal were used, and the forms were modified; ornamentation was added and thin work in embossed patterns gave the stiffness and strength which had been attained before by massive forms. The general types are the ax, first a plain slip of metal, later developed with a socket; then the chisel, gouge, sickle, knife, dagger, sword, spear, and shield; personal objects as pins, necklets, bracelets, earrings, buttons, buckles, and domestic caldrons and cups. Most of these forms were found together, all worn out and broken, in the great bronze-founder's hoard at Bologna.

Lastly in the prehistory of Europe comes the Iron age, which so much belongs to the historical period that we can best consider it in noticing separate countries.

From the recent discoveries in Egypt we can gain some idea of the date of these periods. We ventured to assign about 10,000 B. C. for the rise of the Neolithic or polished stone period (it may very possibly be earlier); the beginning of the use of copper may be placed about 5000 B. C.; the beginning of bronze was perhaps 3000 or 2000 B. C., as its free use in Egypt is not till 1600 B. C.; and the use of iron beginning about 1000 B. C., probably in Armenia, spread thence through Europe until it reached Italy perhaps 700 years B. C., and Britain about 400 B. C. Such is the briefest outline of the greater part of the history of man, massed together in one general term of "prehistoric," before we reach the little fringe of history nearest to our own age. The whole of this knowledge results from the work of this century.

We now turn to the historical ages of each of the principal countries, to review what advance has been made even where a basis of written record has come down to us, equally accessible in all recent times.

EGYPT.

At the beginning of this century Egypt was a land of untouched and inexplicable mystery; the hieroglyphics were wondered at and puzzled over, without any idea of how they were to be read, whether as symbols or as letters. The history was entirely derived from the confused accounts of Greek authors, the lists remaining of Manetho's history written about 260 B. C., and the allusions in the Bible. The attempt to make everything fit to the ideas of the Greeks, and to make everything refer to the Biblical history, greatly retarded the understanding of the monuments, and is scarcely overcome yet. The first great step forward was when an inscription was found at Rosetta in 1799 written in two methods, the monumental hieroglyphic and the popular demotic, along with a Greek version. By 1802 some groups of each writing had been translated. Young identified more signs, and Gell by 1822 could successfully apportion three-quarters of the signs to the Greek words. The next step was to apply the modern Coptic language, descended from the ancient Egyptian, to the reading of the words. Gell had been doing so, but it needed a student of Coptic—Champollion—to carry this out thoroughly, as he did in 1821 to 1832. Since then advance in reading has been only a matter of detail, not requiring any new principles.

The knowledge of the art began with the admiration for the debased work of Roman times, the principal interest at the beginning of the century. Then the excavations among the Rameside monuments at Thebes, about 1820-30, took attention back to the age of 1000-1500 B. C. The work of Lepsius, and later of Mariette, from 1840-80, opened men's eyes to the splendid work of the early dynasties, about 3000-4000 B. C. And lastly the excavations of 1893-99 have fascinated scholars by a view of the rise of the civilization and the prehistoric period before 5000 B. C.

The view that we now have of the rise and decay of this great civilization and its connection with other lands is more complete and far-reaching than that of any other country. In the early undated age before the monarchy which began about 4800 B. C., a flourishing civilization was spread over upper Egypt. Towns were built of brick, as in later times; clothing was made of woven linen and of leather; pottery was most skillfully formed, without the potter's wheel, hand made, yet of exquisite regularity and beauty of outline, while the variety of form is perhaps greater than in any other land; stone vases were made entirely by hand, without a lathe, as perfect in form as the pottery, and of the hardest rocks, as diorite and granite; wood was carved for furniture; the art of colored glazing was common, and was even applied to glazing over large carvings in rock crystal; ornaments and beads were wrought of various stones and precious metals; ivory combs with carved figures adorned the hair; ivory spoons were used at the table; finely formed weapons and tools of copper served where strength was needful, while more useful were flint knives and lances which were wrought with a miraculous finish that has never been reached by any other people; and games were played with dainty pieces made of hard stone and of ivory. But all this tasteful skill of 5000-6000 B. C. had its negative side; in the artistic copying of nature the mechanical skill of these people carried them a very little way; their figures and heads of men and animals are strangely crude. And they had no system of writing, although marks were commonly used. They always buried the body doubled up, and often preserved the head and hands separately. Commerce was already active, and large rowing galleys carried the wares of different countries around the Mediterranean. These people were the same as the modern Kabyle of Algeria and akin to the South European races, but with some negro admixture. Our whole knowledge of this age has only been gained within the last five years.

At about 5000 B. C. there poured into Egypt a very different people, probably from the Red Sea. Having far more artistic taste, a commoner use of metals, a system of writing already begun, and a more organized government, these fresh people started a new civilization in Egypt; adopting readily the art and skill of the earlier race, they formed by their union the peculiar culture known as Egyptian, a type which lasted for 4,000 years. The same foundation of a type is seen in the bodily structure; the early historical people had

wider heads and more slender noses than the prehistoric, but from 4000 B. C. down to Roman times the form shows no change.

From this union of two able races came one of the finest peoples ever seen, the Egyptians of the Old Kingdom, 4500-3500 B. C. Full of grand conceptions, active, able, highly mechanical, and yet splendid artists, they have left behind them the greatest masses of building, the most accurate workmanship and exquisite sculptures in the grand pyramids and tombs of their cemeteries. They perfected the art of organizing combined labor on the immense public works. In all these respects no later age or country has advanced beyond this early ability. The moral character and ideas are preserved to us in the writings of these people; and we there read of the ability, reserve, stadfastness and kindliness which we see reflected in the lifelike portraiture of that age.

After a partial decay about 3000 B. C. this civilization blossomed out again nobly in the twelfth dynasty about 2600 B. C.; though the works of this age hardly reach the high level of the earlier times, yet they are finer than anything that followed them. At this period more contact with other countries is seen; both Syria and the Mediterranean were known, though imperfectly.

To this succeeded another decadence, sealed by the disaster of the foreign invasion of the Hyksos. But this was thrown off by the rise of a third age of brilliance—the XVIIIth dynasty, 1500 B. C.—which, though inferior to early times in its highest work, yet shines by the wide spread of art and luxury throughout the upper classes. Magnificence became fashionable, and the lower classes contented themselves with most barefaced imitations of costly wares. Foreign islands came closely in contact with Egypt. The ships of the Syrian coast and Cyprus continually traded to and fro, exchanging silver, copper and precious stones for the gold of Egypt. Greece also traded its fine pottery of the Mykenæan age for the showy necklace of gold and the rings and amulets with names of Pharaohs. Egypt then dominated the shores of the western Mediterranean, the plains of the Euphrates and the fertile Sudan. But this power and wealth led to disaster. Like Rome, later on, she could not resist the temptation to live on plunder; heavy tribute of corn was exacted, large numbers were employed in unproductive labor, and national disaster was the natural consequence. Egypt never recovered the dominion or the splendor that were hers in this age. Of this period some slight notions are given us from literary remains in the Bible and Greek authors; but archæology is, so far, our only practical guide, as in the earlier ages. The great temples and monuments of the XVIIIth—XXth dynasties (1600-1100 B. C.) bear hundreds of historical inscriptions, the tombs are covered with scenes of private life, the burials and the ruins of towns furnish us with all the objects of daily use. This age is one of the fullest and richest in all history, and hardly any other is better known even in Greece or Italy. Yet all this has been brought to light in this century, and the knowledge of the foreign relations of Egypt is entirely the result of the last fifteen years.

The final thousand years of the civilization of Egypt is checkered with many changes; sometimes independent, as in the ages of Shishak of Necho, and of the Ptolemies; at other times a prey to Ethiopians, Persians, Greeks or Romans. Its arts and crafts show a constant decay, and there was but little left to resist the influence of Greek taste and design, which ran a debased course in the country. There was, however, a spread of manufactures and of cheap luxuries into lower and lower classes; and the wealth of the country accumulated under the beneficent rule of the earlier Ptolemies (300-200 B. C.).

The principal discoveries about these later ages have been in the papyri, which have been largely found during the last twenty years. The details of the government and life of the country in the Ptolemaic (305-30 B. C.) and Roman (30 B. C.-640 A. D.) periods have been cleared up; and many prizes of classical literature have also been recovered. The archæology of the Middle Ages in Egypt has also been studied. Many of the Arabic buildings have been recently cleaned and put in good condition, and the splendid collection of manuscripts in Cairo has opened a view of the beautiful art of the thirteenth-fifteenth centuries so closely akin to what was done in Europe at the same time.

Egypt is then before all other lands the country of archæology. A continuous history of 7,000 years, with abundant remains of every period to illustrate it, and a rich prehistoric age before that, give completeness to the study and the fullest value to archæological research.

MESOPOTAMIA.

The Valley of the Euphrates might well rival that of the Nile if it were scientifically explored, but unhappily all the excavation has been done solely with a view to inscription and sculpture and no proper record has been made, nor have any towns been examined, the only work being in palaces and temples.

The earliest study on the ground was by Rich (1818-20), who gathered some few sculptures and formed an idea of Assyrian art. The French Consul Botta excavated Khorsabad (founded 700 B. C.) in 1834-35, and Layard excavated Nimrud in 1845-47; these were both Assyrian sites. The older Babylonian civilization was touched at Erech by Loftus in 1849-52; and this age has attracted the most important excavations made since, at Tello by Sarzec (1876-81), and at Nippur by Peters and Haynes of Philadelphia during the last few years.

The cuneiform characters were absolutely unexplained until Grotefend in 1800 resolved several of them by taking inscriptions which he presumed might contain names of Persian Kings and comparing them alongside of the known names; thus—without a single fixed point to start from—he tried a series of hypotheses until he found one which fitted the facts. Bournouf (in 1836) and Lassen (1836-44) rectified and completed the alphabet. But the cuneiform signs were used to write many diverse languages, as the Roman alphabet is used at present; and the short Persian alphabet was only a fraction of the great syllabary of 600 signs used for Assyrian. Rawlinson had independently made out the Persian alphabet, using the Zend and Sanskrit for the language. He next, from the trilingual Behistun inscription in Persian, Assyrian and Vannic resolved the long Assyrian syllabary, using Hebrew for the language. Since then other more obscure languages written in cuneiform have been worked with more or less success; the most important is the Turanian language, used by the earlier inhabitants of Babylonia before the Semitic invasion; this is recorded by many syllabaries and dictionaries, and translations compiled by the literary Semitic Kings.

The general view of the civilization which has been obtained by these labors of the century shows it to have been more important to the world than any other. Cuneiform was the literary script of the world for at least 6,000 years, the only medium of writing from the Mediterranean to the Indian Ocean. The Babylonian culture was almost certainly the source of the oldest present civilization—that of China. And the arts were developed probably even earlier than in Egypt. The first inhabitants were called Sumirian (or river folk) in distinction from the Accadian (or highland) people who came from Elam down into the Euphrates Valley, bringing with them the use of writing. Their earliest writing was of figure symbols (like the Egyptian and Hittite); but as in the valley clay tablets were the only material for writing, the figures became gradually transformed into groups of straight lines and spots impressed on the clay; hence the signs were formalized into what we call cuneiform. The Semitic invaders were using cuneiform characters by about 3000 B. C.

The early civilization was intensely religious, the main buildings being the temples, which were placed on enormous piles of brickwork. The sculpture was at a high level in the time of Naram-Sinn, about 3750 B. C.; and yet below his ruins at Nippur there are no less than thirty-five feet depth of earlier ruins, which must extend back to 6000 or 7000 B. C. In early times stone implements were used alongside of copper and bronze, as we find in Egypt 4000 B. C. Pottery was well made, and also reliefs in terra cotta. Personal ornaments of engraved gems and gold work were common.

The main landmarks in the later time of this civilization are the Elamite invasion of Kudur-nan-khundi (2280 B. C.) which upset the Semitic rulers; and the Assyrian invasion of Tiglath-Adar (1270 B. C.), after which interest centers in the Assyrian kingdom and its development of the Mesopotamian culture which it borrowed. The main buildings of the Assyrian kings were their enormous palaces, the mass of which was of unbaked bricks, faced with alabaster slabs; such were the works of Assurnazir-pal (Nimrud, 880 B. C.), Sargon (Khorsabad, 710 B. C.), Sennacherib and Assurbani-pal (Kouyunjik, 700 B. C.). The later, Assyrian, form of the civilization was to the earlier Chaldean much what Rome was to Greece, a rather clumsy borrower who laboriously preserved the literature and art. Some of the Assyrian sculpture of animals is, however, perhaps unsurpassed for vivid action. The systematic libraries, containing copies of all the older literature for general study, were most creditable, though the Assyrian himself composed nothing better than chronicles. Nearly all that we possess of Babylonian religion, and much of the history, is in the copies scrupulously made from the ancient tablets by the Assyrian scribes, who noted every defect in the original with critical fidelity.

The Mesopotamian civilization has left its mark on the modern world. Its religion greatly influenced Hebrew, and thence Christian, thought, the Psalms, for instance, being a Babylonian form of piety. Its science fixed the signs of the Zodiac, the months of the year, the days of the week, and the division of the circle in degrees, all of which are now universal. And its art, carried by the Phœnicians, was copied by the Greeks and Etruscans, and thus passed on into modern design.

(To be continued.)

SATURN'S RINGS.

By HAROLD JACOBY, Professor of Astronomy in Columbia University.

THE sudden death of James E. Keeler, Director of the Lick Observatory in California, recalls to mind one of the most interesting and significant of recent advances in astronomical science. Only five years have elapsed since Keeler made the remarkable spectroscopic observations which gave for the first time an ocular demonstration of the true character of those mysterious luminous rings surrounding the brilliant planet Saturn. Although these observations were carried out five years ago, they have not yet been made sufficiently accessible to the public at large, nor have they been generally valued at their true worth. We have called this work of Keeler's interesting, because the problem of the rings has been a classic one for many generations; and we have been particular, also, to call it significant, because it is pregnant with the possibilities of newer methods of spectroscopic research, applied to the older departments of observational astronomy.

The troubles of astronomers with the rings began with the invention of the telescope itself. They date back to 1610, when Galileo first turned his new instrument to the heavens. It may be imagined easily that the bright planet Saturn was among the very first objects scrutinized by him. His "powerful" instrument magnified only about thirty times, and was doubtless much inferior to our pocket telescopes of today. But it showed at all events that something was wrong with Saturn. Galileo put it, "Ultimam planetam tergeminam observavi," "I have observed the furthest planet to be triple." It is easy to see now how Galileo's eyes deceived him. For a round luminous ball like Saturn, surrounded by a thin flat ring seen nearly edgeways, really looks as if it had two little attached appendages.

A PUZZLING PLANET.

Galileo's further observations of Saturn bothered him more and more. The planet's behavior became much worse as time went on. "Has Saturn devoured his children, according to the old legend?" he inquired soon afterward. For the changed positions of earth and planet in the course of their motions around the sun in their respective orbits had become such that the ring was seen quite edgewise, and was, therefore, perfectly invisible to Galileo's "optic tube." The puzzle remained unsolved by Galileo; it was left for another great man to find the true answer. Huygens, in 1656, first announced that the ring was a ring.

The manner in which this announcement was made is characteristic of the time; today it seems almost ludicrous. Huygens published a little pamphlet in 1656 called "De Saturni Luna Observatio Nova," or, "A New Observation of Saturn's Moon." He gave the explanation of what had been observed by himself and preceding astronomers in the form of a puzzle, or "logogriph." Here is what he had to say of the phenomenon in question: "aaaaaaa ccccc d eeeee g h iiiiiii llll mm nnnnnnnnn oooo pp q rr s ttttt uuuuu." It was not until 1659, three years later, in a book entitled "Systema Saturnium," that Huygens rearranged the above letters in their proper order, giving the Latin sentence: "Annulo cingitur, tenui plano, nusquam cohaerente, ad eclipticam inclinato." Translated into English, this sentence informs us that the planet "is girdled with a thin, flat ring, nowhere touching Saturn, and inclined to the ecliptic!" This was a perfectly correct and wonderfully sagacious explanation of those complex and exasperatingly puzzling phenomena that had been too difficult for the masterhand of Galileo himself. It was an explanation that explained.

But of far greater interest than the mere fact of their existence is the important cosmic question as to the constitution, structure, and, above all, durability of the ring system. Astronomers often use the term "stability" with regard to celestial systems like the ring system of Saturn. By this they mean permanent durability. A system is stable if its various parts can continue in their present relationship to one another, without violating any of the known laws of astronomy. Whenever we study any collection of celestial objects, and endeavor to explain their motions and peculiarities, we always seek some explanation not inconsistent with the continued existence of the phenomena in question. For this there is perhaps no sufficient philosophical basis. Probably much of the great celestial procession is but a passing show, to be but for a moment in the endless vista of cosmic time.

However this may be, we are bound to asume that Saturn has always had these rings, and will always have them; and it is for us to find out how this is possible. The problem was first attacked mathematically by various astronomers, including Laplace; but no conclusive mathematical treatment was obtained until 1857, when James Clerk Maxwell proved in a masterly manner that the rings could be neither solid nor liquid. He showed, indeed, that they would not last if they were continuous bodies like the planets. A big solid wheel would inevitably be torn asunder by any slight disturbance, and then precipitated upon the planet's surface. Therefore, the rings must be composed of an immense number of small detached particles, revolving around Saturn in separate orbits, like so many tiny satellites.

THE "ASTEROIDS" ANALOGY.

This mathematical theory of the ring system being once established, astronomers were more eager than ever to obtain a visual confirmation of it. We had indeed a sort of analogy in the assemblage of so-called "minor planets" or "asteroids," which are known to be revolving around our sun in orbits situated between Mars and Jupiter. Some hundreds of these are known to exist, and probably there are countless others too small for us to see. Such a swarm of tiny particles of luminous matter would certainly give the impression of a continuous solid body, if seen from a distance comparable to that separating us from Saturn. But arguments founded on analogy are of comparatively little value. Astronomers need direct and conclusive telescopic evidence, and this was lacking until Keeler made his remarkable spectroscopic observations in 1895. The spectroscope is a peculiar instrument, different in principle from any other used in astronomy; we study distant objects with it by analyzing the light they send us, rather than by examining and measuring the details of their visible surfaces. The reader will recall that according to the modern undulatory theory, light consists simply of a series of waves. Now the nature of waves is very far from being understood in the popular mind. Most people, for instance, think that the waves of ocean consist of great masses of water rolling along the surface. This notion doubtless arises from the behavior of waves when they break upon the shore, forming what we call "surf." When a wave meets with an immovable body like a sand-beach, the wave is broken and the water really does roll upon the beach. But this is an exceptional case. Farther away from the shore, where the waves are unimpeded, they consist simply of particles of water moving straight up and down. None of the water is carried by mere wave action away from the point over which it was situated at first. Tides or other causes may move the water, but not simple wave motion alone. That this is so can be proved easily. If a chip of wood be thrown overboard from a ship at sea it will be seen to rise and fall a long time on the waves, but it will not move. Similarly, wind waves are often quite conspicuous on a field of grain; but they are caused by the individual grain particles moving up and down. The grain cannot travel over the ground, since each particle is fast to its own stalk.

But while the particles do not travel, the wave disturbance does. At times it is transmitted to a considerable distance from the point where it was first set in motion. Thus, when a stone is dropped into still water, the disturbance (though not the water) travels in ever-widening circles, until at last it becomes too feeble for us to perceive. Light is just such a traveling wave disturbance. Beginning, perhaps, in some distant star, it travels through space, and finally the wave impinges on our eyes like the ocean wave breaking on a sand beach. Such a light-wave affects the eye in some mysterious way we call "seeing."

KEELER AND THE SPECTROSCOPE.

The spectroscope enables us to count how many waves reach us each second from any given source of light. No matter how far away the source of stellar light may be, the spectroscope examines the character of that light, and tells us the number of waves set up

every second. It is this characteristic of the instrument that has enabled us to make some of the most remarkable observations of modern times. If the distant star is approaching us in space, more light-waves per second will reach us than we should receive from the same star at rest. Thus, if we find from the spectroscope that there are too many waves, we know that the star is coming nearer; and if there are too few, we can conclude with equal certainty that the star is receding. Keeler was able to apply the spectroscope in this way to the planet Saturn and to the ring system. The observations required dexterity and observational manipulative skill in a superlative degree. These Keeler had; and this work of his will always rank as a classic observation. He found by examining the light-waves from opposite sides of the planet that the luminous ball rotated; for one side was approaching us and the other receding. This observation was, of course, in accord with the known fact of Saturn's rotation on his axis. But with regard to the rings, Keeler showed in the same way the existence of an axial rotation, which appears not to have been satisfactorily proved before, strange as it may seem. But the crucial point established by the spectroscope was that the interior part of the rings rotates faster than the exterior. The velocity of rotation diminishes gradually from the inside to the outside. This fact is absolutely inconsistent with the motion of a solid ring; but it fits in admirably with the theory of a ring composed of a vast assemblage of small separate particles. Thus, for the first time, astronomy comes into possession of an observational determination of the nature of Saturn's rings, and Galileo's puzzle is forever solved.—New York Evening Post.

METEOROLOGICAL INSTRUMENTS.

By Prof. Hans Hartl.

The world is completely surrounded by an envelop of air, some twenty miles in thickness. This envelop, which we call the atmosphere, consists primarily of

Fig. 1.—A CENTIGRADE THERMOMETER.

oxygen and nitrogen, mingled with small quantities of various other gases and with considerable moisture in the form of watery vapor. Like terrestrial solids and fluids, the atmosphere is held in place by the attraction of the earth. By reason of this attraction the envelop of air exerts a certain pressure on the earth, which pressure is termed atmospheric pressure. Per square inch, the atmospheric pressure amounts to about fifteen pounds. Since the surface of the earth has an area of two trillion square inches it follows that the total weight of the atmosphere is about thirty trillion pounds.*

By reason of its extreme expansibility and mobility, the atmosphere is subject to constant changes which give rise to variations in the pressure. Besides these changes, there are also variations in temperature and humidity.

Since the organic life which flourishes at the bottom of the ocean of air is influenced by atmospheric conditions, it is of great interest as well as of importance accurately to study these conditions. Our senses are most untrustworthy in scientific research. To be sure, we feel plainly enough whether the air be warm or cold, whether the velocity of the wind be small or great, whether the atmosphere be humid or dry. But these sensations are not sufficiently well defined to enable us to gauge accurately the condition of the air. The temperature, pressure, humidity and velocity of the air can be measured only by means of meteorological instruments. Such instruments can be divided into four classes—those which measure heat (thermometers), those which measure pressure (barometers), those which measure humidity (hygrometers), those which measure wind velocities (anemometers).

Thermometers are based upon the principle that bodies expand when heated and contract when cold. The ordinary thermometer (Fig. 1) consists of a glass tube provided at its lower end with a bulb. The tube is partially filled with mercury; and above the mercury is a vacuum. The tube is attached to a scale. If the thermometer be placed in melting ice, the mercury sinks in the tube to the point marked O on the scale (the freezing-point of water on the centigrade thermometer). If the thermometer be placed in boiling water or in steam, the mercury rises to the point marked 100 on the scale (the boiling-point of water on the centigrade scale). The space between these two points is divided into 100 equal parts, the graduation being also continued below the zero mark. The degrees above zero register heat; those below, record the degree of cold. The thermometer illustrated in Fig. 1 is indicating 16 deg. C. It will be observed that, in this instrument, which is used only in measuring the temperature of the air, the maximum and minimum points of the scale are + 50 deg. and — 30 deg. Instead of mercury colored spirits or creosote can be employed.

In the maximum and minimum thermometer shown in Fig. 2* the heat measurer used is creosote or alcohol.

The instrument consists of a U-shaped glass tube, *a b*, formed with enlargements, *A B*. The lower portion of the tube contains mercury, above which is a layer of creosote in both legs. The enlargement, *A*, constituting a receptacle, is filled with creosote down

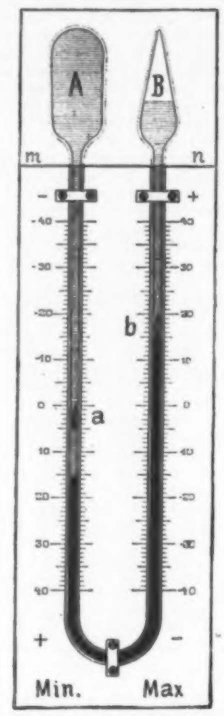


Fig. 2.—MAXIMUM AND MINIMUM THERMOMETER.

to *a*, in the right portion of the instrument. The enlargement or receptacle, *B*, is only partially filled with creosote. The upper portion of the receptacle, *B*, contains air mingled with creosote vapors. The creosote in the receptacle, *A*, is the actual thermometric body, the mercury serving only to indicate upon the scale the degree of expansion to which the creosote is subjected by heat. The creosote in the receptacle, *A*, expands, causing the mercury to fall in the leg, *a*, and to rise in the leg, *b*. On the scales of both legs the same degree of heat is indicated (in Fig. 2, 15 deg.). In the right leg the mercury stands above zero, in the left leg below zero. When the temperature falls the creosote in the receptacle, *A*, contracts; and the mercury, by reason of the pressure of the creosote vapors in the receptacle, *B*, is forced up into the leg, *a*.

A hasty examination of this instrument might lead one to infer that it is but a very awkwardly-constructed creosote-thermometer with a double scale. The instrument is, however, thus constructed for the purpose, not only of marking the temperature of the moment, but also of indicating the minimum temperature registered during the night and the maximum temperature attained on the previous day. In both legs of the thermometer small steel indices floating on the mercury are contained, about which indices elastic glass threads are wound, the glass threads having sufficient resiliency to engage the glass walls of the corresponding legs of the thermometer. It follows, therefore, that the one steel index will remain at the maximum point to which it has been pushed by the mercury in the one leg. Every morning the steel indices are brought into contact with the mercury by means of magnets. If during the course of the day the temperature rises to 20 deg. C. the mercury mounts in the right leg and forces the floating steel index to the 20 deg. mark. If the mercury fall, the index clings to the glass and indicates the maximum temperature of the day. If in the following night the temperature drop to +8C. the mercury rises in the left leg and pushes the index in that leg up to the mark + 8. If the temperature then rise, the mercury falls in the left leg, leaving the index in position at the mark + 8. On the following morning it will be seen that the maximum temperature attained in the previous twenty-four hours was

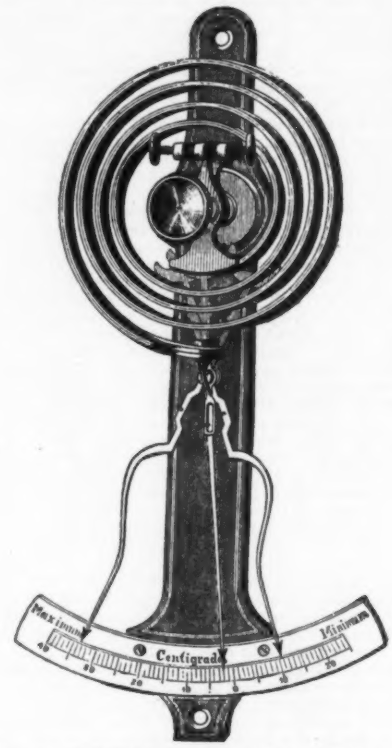


Fig. 3.—PFISTER-HERRMANN METALLIC THERMOMETER.

20 deg., the minimum temperature + 8. The instrument is therefore very properly called a maximum and minimum thermometer.

The mean between the maximum and minimum temperature (20 + 8÷2 = 14 deg. in the present case) will as a general rule, be found approximately equal to the temperature at 8 A. M. of the twenty-four hours under consideration. For this reason the temperature read at 8 o'clock in the morning is usually taken in weather forecasts, as the mean temperature of the day.

In another class of thermometers, the difference in expansion of two metals is employed as a means of measuring heat. A rod of iron, for example, one meter in length when removed from a vessel of ice water and plunged into a vessel of boiling water, will expand only one millimeter; whereas a rod of zinc, also one meter in length, will, under similar conditions, expand three millimeters. If two such straight rods or straps of iron and zinc be riveted or soldered together, and plunged in boiling water, they must assume such a form that the zinc strap will become 1003 millimeters long and the iron strap 1001 millimeters long. But since the solder or rivets prevent the straps from sliding on each other, the form assumed must of necessity be an arc with the zinc strap forming the longer, outer curve. The higher the temperature the more pronounced will be the curve of the arc.

The metallic thermometer of Pfister and Herrmann (Fig. 3) consists of a coiled zinc ribbon, the inner end of which is fastened to a backboard. When the temperature rises, the ribbon bends more sharply inward, the free outer end moving to the right. A pivoted finger, the shorter arm of which is connected with the end of the coil, plays over a scale and multiplies the variations in the length of the spiral to such an extent that they may be read off in degrees of heat on the scale. Sometimes two auxiliary fingers are employed, which are not connected with the coil, and which are

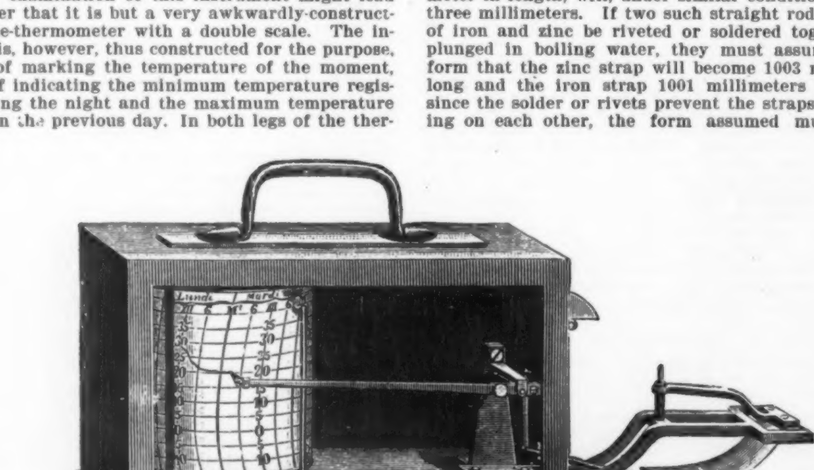


Fig. 4.—A THERMOGRAPH.

* Of the enormity of these values, some idea may be obtained by instituting a few interesting comparisons. One million trains each composed of one million powerful locomotives would represent but the hundredth part of the weight of the atmosphere. A leaden ball equal in weight to the atmosphere would have a diameter of 12½ miles. If the earth were covered with a layer of mercury 760 mm. (30 inches) high, the superimposed weight would equal that of the atmosphere.

* Only the portion below the line, *m n*, is visible, the parts, *A B*, being incased.

so mounted that they are held in any position by the friction of their surfaces. As the central or main finger under the influence of the coil moves to the right or to the left, it will force one of the auxiliary fingers along the scale. Since these auxiliary fingers remain wherever they are moved, the maximum and minimum temperatures of the day are indicated.

Another heat-measuring instrument, which not only indicates present temperatures but also records the temperature attained at any given moment is the thermograph shown in Fig. 4. The principal part of the instrument is an elastic metallic tube filled with alcohol and secured at its upper end to a yoke-like frame. The other, free end is connected with an indicator by means of a compound lever, which multiplies the degree of expansion of the metallic tube. The end of the indicator carries a pen which traces a record upon a strip of paper ruled vertically and horizontally. The vertical lines are ordinates of time, and the horizontal lines abscissas of temperature. The strip of paper is passed around a drum driven by a clock-train, so that the indicator will be located on the proper ordinate at the exact time designated by that ordinate. Simultaneously the temperature will be marked by the indicator. Each week the paper with its record is removed and a new strip inserted.

FIG. 5A.

FIG. 5B.

A LAMBRECHT BAROMETER.

It is a phenomenon well known to every one that the mercury contained in a vacuum-tube will be driven up until its pressure exactly counterbalances that of the atmosphere. At the level of the sea, the height of the column of mercury at normal atmospheric pressure will be about 30 inches. When the pressure increases, the mercury is driven up; when the pressure decreases the mercury sinks. By measuring the height of the column of mercury it is therefore possible to ascertain the pressure of the atmosphere. A mercury-tube of this type constitutes a barometer.

Figs. 5A and 5B represent a Lambrecht barometer, one of the most accurate instruments used in meteorological research. The glass-tube is enlarged at the top, in order to prevent the capillary depression of the level of the mercury. By means of a so-called Bunten point, the minute bubbles of air, which are contained in the mercury, are prevented from passing up into the Toricellian vacuum. The height of the mercury is measured by means of a float provided with a vernier, so that the tenth part of a millimeter can be accurately read. In order that the eye may be in correct position relatively to the level of the mercury, a vertical mirror is mounted behind the glass tube. The millimeter scale is engraved on a steel ruler, forked at its lower end. One of the tines of this fork, which indicates the zero point of the scale, projects into the cistern in which the mercury is contained (Fig 6). By means of a screw extending upwardly into the cistern, the level of the mercury is adjusted to the zero point of the scale. A correction in all readings must be made for temperature, since the height of the column of mercury varies with the heat of the surrounding atmosphere. In order to make the necessary correction the height, B, of the mercury is interpreted in

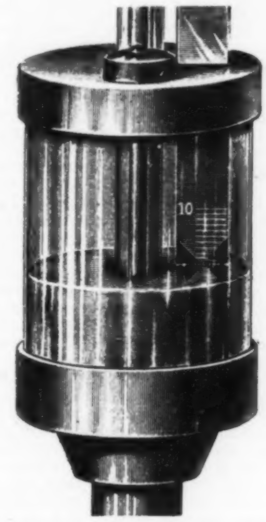


FIG. 6.—THE MERCURY CISTERN OF A BAROMETER.

terms of the height, b, at which the mercury would stand were its temperature 0 deg. C. The height, b, is obtained by the formula:

$$b = \frac{B}{1 + 0.00018\,t}$$

in which t denotes the temperature indicated by the thermometer on the barometer backboard. If it be assumed that the height, B, of the mercury in the tube is 732 millimeters, and t is equal to 15, then

$$b = \frac{732}{1 + 0.00018 \times 15} = \frac{732}{1 + 0.0027}$$

$$= \frac{732}{1\ 0027} = 730 \text{ millimeters.}$$

In this manner all barometric readings must be converted into terms of 0 deg. C. The thermometer employed in connection with the Lambrecht barometer obviates this mathematical reduction; for it indicates on a scale the number of millimeters which must be deducted from the actual height of the barometric mercury to obtain an absolutely correct result in terms of 0 deg. C.

It is of the utmost importance to ascertain the atmospheric pressure in various parts of a large area. For if the pressure be known the direction of the atmospheric currents and the meteorological conditions which are likely to prevail may be determined. At those places where the barometer stands high, fine weather with gentle winds is apt to prevail; at places where the barometer stands low, stormy weather may be looked for. In order to forecast the weather, meteorological bureaus daily receive telegraphic information of the barometric conditions throughout the country. Those places at which the height of the barometer is the same are connected by lines on previously prepared maps, and these lines are termed "isobars."

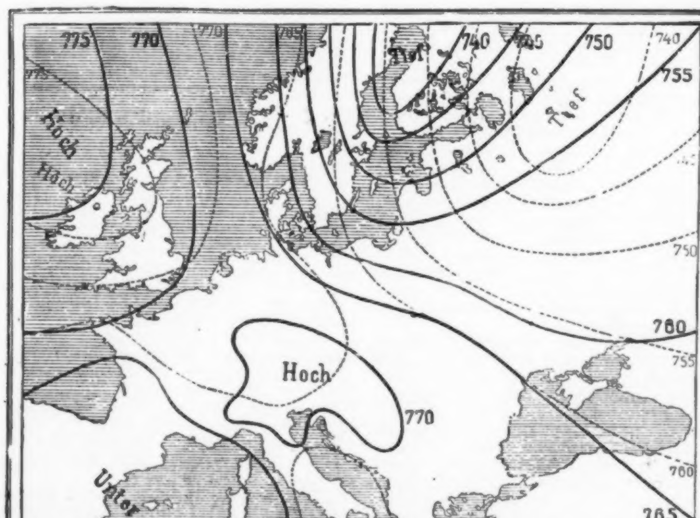


FIG. 7.—AUSTRIAN WEATHER-CHART.

In this manner the weather maps are made, which are sent out each day from the various bureaus. In Fig. 7 we have reproduced a map for Sept. 12-13, 1894, issued by the Austrian Weather Bureau. The isobars for the twelfth of September are full; those for the thirteenth are dotted.

In plotting out the isobars, the weather-bureau officials are compelled to make various corrections. If observations are made in the same city by two men, both of whom are using accurate instruments, but one of whom is at a greater elevation than the other, it is evident that the two readings will not coincide. For the barometer at the higher elevation will be subject to less pressure than the other barometer. Evidently a correction must be made. It is the custom to reduce all barometric readings to a common level; and the level chosen is that of the sea. Most weather-bureaus employ a conversion-table similar to the following:

TABLE FOR DETERMINING BAROMETRIC HEIGHTS AT THE LEVEL OF THE SEA.

Temperature of Air (Centigrade.)	Observed Height of Barometer (Millimeters).*						
	760	750	740	730	720	710	700
− 5°	10.3	10.4	10 6	10.7	10.9	11.0	11.2
0	10.5	10.7	10.8	**10.9**	11.1	11.3	11.4
+ 5	10.7	10.9	11 0	11.2	11.3	11 5	11.6
10	10.9	11.1	11 2	11.4	11 5	11.7	11 9
15	11.1	11.3	11.4	11 6	11.8	11 9	12.1
20	11.4	11 5	11.7	11 8	12.0	12.2	12.3
25	11.6	11.7	11 9	12.0	12.2	12.4	12 5
30	11.8	11.9	12.1	12.2	12.4	12.6	12.8
35	11.9	12.1	12.3	12.4	12.6	12.8	13.1

* For mercury barometers, the observed height must be read in terms of 0° C., as previously described.

If at an elevation of 374 meters the barometer be observed to stand at 730 mm. at a temperature of 0 deg. C., then by referring to the table it will be seen that the number opposite 0 deg. in the column 730 is 10.9. The observer then knows that a difference in elevation of 10.9 meters between two points is equivalent to a difference of 1 mm. in barometric pressure under the conditions cited. If therefore the barometers were situated at the sea-level, or, in other words, lowered 374 meters, the mercury would rise 374 ÷ 10.9 = 34.3 millimeters, which, added to the 730 millimeters originally indicated, gives as a result 764.3 millimeters. Only readings thus reduced are marked on weather maps.

(To be continued.)

NEW WIND-RECORDING APPARATUS.

A NEW apparatus for recording eight directions of the wind by means of two styles has been adopted at the Agricultural College of Berlin. The general arrangement is that introduced by Herr Sprung. A current-distributor follows the movement of the vane. This distributor consists of a platinum sector of 135 degrees, turning about a vertical axis over four platinum contacts, connected with four electro-magnets. The axis is joined to the one pole of an accumulator-cell. The electro-magnets are arranged in two pairs corresponding to the wind directions, north-south, east-west. In front of each of the pairs swings a pendulum, provided with an oil damper. A deflection in the one pendulum to the left means north wind, to the right, south wind; the deflections of the other pair indicate east and west wind, and the combination of the two simultaneous movements gives the intermediate directions. The pens are attached to the ends of the pendulums, and draw parallel curves on a paper tape, which is being pulled downward by a small weight. If a continuous record is desired, the common return from the four electro-magnets is taken directly back to the other pole of the cell. At Berlin, however, a relay is interposed whose circuit is, by means of clockwork, which also releases the tape, energized every three minutes. Thus twenty wind-records are obtained per hour.

[Continued from SUPPLEMENT, No. 1307, page 20953.]

RECENT SCIENCE.*

I. UNSUSPECTED RADIATIONS—CONTINUED.

THE pernicious effects of the invisible rays on the skin are now eliminated by shortening the time of exposure which is required to obtain a good radiogram, and the morbid effects have been traced by Russian explorers (Danilevsky, Tarkhanoff) to electric radiations altogether, rather than to the X-rays themselves. Formerly it required eighteen minutes to obtain a radiogram of the hand. Now we are told that Dr. Donath obtains in two seconds a distinct radiogram of so difficult a subject as the shoulder and the chest; while Tesla, with his powerful alternate currents, could show distinct shadows at a distance of 165 feet from the vacuum tube. In the hands of an able surgeon—as Prof. E. Bergmann illustrated before the Association of German Naturalists and Physicians in 1899—the X rays become a most precious means of exploration. The growth of the bones, from birth till matured age, could be studied with their aid, and the various causes which retard growth (rachitism, tuberculosis) or produce midgets could be ascertained. The fearful splintering of the bones by the modern bullets, and especially by the English dum-dum bullet, became known, and the radiograms of Bruns showing the effect of the dum-dum provoked on the continent a unanimous indignation against this bullet. Many limbs were saved during the last Greek-Turkish war by Nasse and Kuttner continually resorting to radiography. So also in the Soudan war. In fractures of the kneecap the Roentgen rays have proved simply invaluable. But perhaps the best service they rendered was to demonstrate that in many cases it was far preferable to leave pellets of lead, small revolver bullets, and even Peabody-Martini bullets where they were lodged in the tissues instead of trying to get them out. In fact, Dr. Bergmann's radiograms prove that a bullet may sometimes remain even in the lungs without occasioning any trouble. Such was the case of a German soldier who had carried a bullet in his lungs for twenty-nine years, since 1871, without knowing it. The German professor goes even so far as to maintain that there are cases when a small bullet lodged in the white mass of the brain will remain there firmly imbedded, without producing any noticeable trouble, and that there is less danger in leaving it there than in extracting it.

If Roentgen's discovery had only the effect of alleviating so many human miseries, it would already rank among the great achievements of the century. But its profound effects upon natural philosophy are far from being yet exhausted.

Every one knows the phosphorescent match-boxes provided with a white surface, which is usually protected from moisture by a glass, and glows in the darkness, making the box visible at night. Sulphide of lime is generally used for making such glowing surfaces, but various compounds of barium, calcium, strontium, uranium and so on possess the same property of glowing in the dark after they have been exposed for some time to light. They are said, in this case, to "store up" light energy, which they give away afterward; this was, at least, the explanation that used to be given some time ago.[21] Now, it was in this rather neglected domain that Henri Becquerel discovered the wonderful radiations which have received his name, and which, owing to the speculations they provoked as regards the theory of matter, have engrossed for the last four years the attention of physicists, even more than the Roentgen rays themselves.

It will be remembered that a phosphorescent screen which began to glow in the proximity of a vacuum tube upon which Roentgen was experimenting led him to his memorable discovery. It was only natural, therefore, to see whether phosphorescent screens would not reinforce the X-rays; and in the course of such experiments M. Henry noticed that a phosphorescent sulphide of zinc gave up radiations which, like the Roentgen rays, would pass through black paper, and affect after that the photographic plate.[22] M. Niewenglowski, also at Paris, made the same remark concerning a sulphide of lime previously exposed to light.[23] Then, at the next sitting of the Paris Academy of Sciences Henri Becquerel came forward with a work on the radiations emitted by phosphorescent substances,[24] and this first work was followed by quite a number of papers, in which the new radiations were studied under all possible aspects. Becquerel was joined in his researches by many others, and especially by Mme. Sklodowska Curie and her husband, M. Pierre Curie, who soon discovered, with the aid of the new radiations, two new elements, and by this time the "Becquerel rays" have already a bulky literature. During the past year nearly every week brought with it the discovery of some new and puzzling property of these radiations.[25]

The main point of the discovery was that phosphorescent bodies emit not only the well-known glow, which is visible to our eye, but also invisible radiations, similar to the Roentgen rays. Some salts of the metal uranium, and the metal itself, need not be exposed to light for more than one-hundredth part of a second to begin to glow, and long after the glow has disappeared they continue to send out the invisible radiations affecting the photographic film for months, and even years, as it appeared later on, even though the salt or the metal remained all the time in a closed box locked in a drawer in a dark room. The Becquerel radiations are thus quite different from phosphorescence or fluorescence. They are similar in nature to the cathode rays and the Roentgen rays, with one substantial difference only. In the vacuum tube we know the force—electricity—which supplies the energy for setting the atoms or the molecules of the gas into motion; while here we see no such source of energy—the radiations continue months and years after the phosphorescent body has seen the light, and there is no notable diminution of its radiating activity. Besides, certain substances need not be influenced by light at all for sending out radiations, and this property belongs, as it appeared later on, not only to phosphorescent bodies, but to a great variety of substances, organic and inorganic; so that one has to ask one's self whether the Becquerel radiations are not a property of matter altogether.

The first experiments of Becquerel were these: A little lamina of the double sulphide of uranium and potassium, which has a great phosphorescing power, was placed upon a black paper envelope containing a photographic film. A glass plate, or a thin plate of aluminium or of copper, was introduced between the two, and the whole was either exposed to diffused daylight or closed in a black box and put in a drawer. In a short time in the first case—in a few hours in the second—the photographic film would show that some rays had been radiated from the sulphide. They had traversed the paper and partly also the metals, though less so than the paper, and the plate bore the image or the shadow of the piece of copper.

The analogy with the Roentgen rays was thus evident, and further inquiry confirmed it. Like the cathode rays, the Becquerel radiations are deflected from their rectilinear paths by a magnet; but, like the Roentgen rays, they cannot be reflected, or broken, or polarized.[26] And, like the cathode rays, they render the air through which they pass a conductor of electricity; they carry electricity with them, and consequently it is most probable that they are not vibrations of the ether, but electrified particles of matter, or *ions*, like the cathode rays. And so we have the puzzle, or, at least, the quite unexpected fact, of matter radiating molecules without any electrical, or luminous, or heating cause provoking and maintaining that radiation or evaporation.

The Becquerel rays, as was just said, send electrified particles which are capable of neutralizing the electricity of other bodies with which they come into contact. The gold leaflets of a charged electroscope drop at the contact with them.[27] But Becquerel was not satisfied with merely stating this fact; he immediately devised a very delicate instrument for *measuring* the activity of different rays given up by various bodies. Perhaps he did not realize that he was thus endowing science with a new method of analysis, which would lead, like spectrum analysis, to the discovery of new elements; but in the hands of M. Curie and Mme. Sklodowska-Curie, this method really led to the discovery of at least one element, radium, and perhaps two more—polonium and actinium.

From the very outset it became evident that compounds of uranium, and especially the metal itself, prepared in a pure state by Moissan in his electric furnace, were possessed of the greatest radio-activity. Thorium with its compounds came next. As to the other elements, nearly all of which were examined by Mme. Sklodowska, they were all much inferior to these two. It was also noticed during these researches that, as a rule, the compounds were inferior to the pure metals themselves. One mineral, however, the Bohemian pitchblende, as also two others of less importance—all compounds of uranium—proved to be much more radio-active than pure uranium itself, and M. and Mme. Curie, suspecting that the pitchblende must contain some new substance more active than uranium, began a most painstaking laboratory work in order to isolate that special substance. They obtained at last a metal, identical as to its chemical properties with bismuth, but far more radio-active, and they named it *polonium*, in honor of Mme. Sklodowska's fatherland. Then, beginning once more, in company with G. Bémont, the whole research from the beginning, in order to hunt for another very radio-active substance of which they had suspected the existence, they obtained another metal similar to barium by its chemical properties, but still more radio-active, which they named *radium*.[28] And finally A. Debierne has discovered lately by the same method a third element named *actinium* and chemically similar to totanium.[29] Mr. Crookes, while disagreeing with the Curies as regards their new elements, came also, after a long research, to some new element, or at least to some new variety of uranium, which he named "Ur X," and which in his opinion is neither polonium nor radium.[30] The new method of "radiation analysis" has thus completed its proofs.

Of course, so long as these new elements have not been separated chemically from their nearest of kin—bismuth, barium, and titanium—their existence must still remain doubtful. But the spectrum of radium has already been examined by Demarçay[31] and by Dr. C. Runge under a very great dispersion; and the great German specialist in spectra found that radium really gives three distinct lines which belong to no other element.[32]

The radio-activity of these new metals is really striking. For polonium it is 400 times, and for radium 900 times, greater than for metallic uranium. Radium illuminates a phosphorescent screen indefinitely, and its salts glow without requiring for that a preliminary excitement by light. F. Giesel, who almost simultaneously with the Curies obtained a substance that must be radium, saw the chloride and bromide of this substance, although chemically identical with the same compounds of barium, sending such strong rays that the shadow of a hand appeared on a phosphorescent screen at a distance of 18 inches and the rays pierced metallic plates 4-10 and 8-10 of an inch thick. Salts containing an admixture of the new substance were so phosphorescent that one could read in their blue light. As to polonium, although a pure specimen of it was as phosphorescent as pure radium, its invisible rays had, however, a much smaller penetrating power: even cardboard would weaken them.[33]

The main interest of these researches is, however, in the problematic nature of the Becquerel radiations. Are they not a general property of matter, only varying in degree in different substances?—this is the question which is now asked. Some thirty or thirty-five years ago it was mentioned in some scientific reviews that various objects—a printed page or a piece of metal—left their impressions on a white sheet of paper if the two had been kept for some time at a small distance from each other. These experiments, which seemed to prove the existence of some sort of radiation of matter, interested me then a great deal because they gave support to a very ingenious theory, developed by Séguin, concerning the existence of infinitely small particles of matter dashing in all directions through space and penetrating matter. With the aid of these particles, Séguin endeavored to explain gravitation, heat, light, and electricity. Now W. J. Russell, continuing the experiments of Colson on zinc and other metals,[34] laid before the Royal Society in the autumn of 1897, and later on, with more details, in a Bakerian lecture, experiments having very much the same purport. He found that certain metals (magnesium, cadmium, zinc, nickel, etc.) and certain organic bodies (printing-ink, varnishes) will act on a photographic plate by their "emanations," exactly as if the plate had been acted upon by light—the boiled oil of the printing-ink and the turpentine in varnish being the active substances. Remarkably clear photographs of a printed page and a lithographic print were thus obtained without the aid of light. Many organic substances act in the same way, and a piece of old dry board gives its likeness simply after having been laid for some time over a photographic film; while a plate of polished zinc, separated from the film by a sheet of paper, will send its radiations through the paper and give a photographic reproduction of its water-marks.[35]

In what relation these "emanations" stand to the Becquerel rays cannot yet be determined. But it becomes more and more certain that, like the cathode rays, the Becquerel radiations also consist of material particles projected from the radio-active bodies and carrying electricity with them. They may possibly be accompanied by vibrations of ether of the nature of light, but the fact of a real transport of particles of matter is rendered more and more apparent by the researches of Becquerel, the Curies, Elster, and Geitel,[36] and Rutherford.[37] The "emanations" from thorium compounds are even affected by draughts in the room. But these emanations are neither dust nor vapors. They must be atoms, or *ions* of the radiating body, and they communicate radio-activity, and consequently the power of discharging electricity, to the surfaces of the bodies with which they come in contact. From glass that "acquired" activity may be washed away, while to other bodies it clings like a sprinkling of the "jack-frost" powder, and M. Curie is described in Nature as being unable for a time to make electrostatic experiments on account of this "acquired" radio-activity.[38] Moreover, the Becquerel radiations exercise a chemical action; they ozonify air, as they "ionize" it, and a glass bottle which contains salts of radium takes a violet color, thus showing that chemical processes are provoked by the radiations.[39]

Many problems relative to the structure and *life* of matter have thus been raised by these researches. Various hypotheses are offered to explain them, and J. J. Thomson's hypothesis—a further development of his cathode-rays hypothesis—appears, after all, the most probable. The molecules of which all bodies are composed are not something rigid. They *live;* that is, an atom or a "corpuscle" is continually being detached from this or that molecule and it wanders through the gas, the liquid, or even through the solid;[40] another atom (or corpuscle) may next take its place in the broken molecule, and so a continual exchange of matter takes place within the gaseous, liquid, or solid bodies, the wandering "corpuscles" always carrying with them the sort of motion which we call an electrical charge. Those atoms or corpuscles which escape from the surface of the body would give what we call now Becquerel rays, and it would not be a simple coincidence that those two elements which possess the greatest atomic weights, and consequently have the most complex molecules,[41] possess also the highest radio-activity. We know that in solutions the so-called unstable compounds play an immense part: they are continually broken up, losing part of their atoms, and are continually reconstituted as they take in new atoms. And we know that in living matter the most compound molecules—those of albumen—are those which are split up most easily,

* Prince Kropotkin, in The Nineteenth Century. Reprinted by permission of the Leonard Scott Publication Company.

[21] The terms "phosphorescence" and "fluorescence" are rather indiscriminately used to describe glowing after an exposure to light, as the distinction between the two, proposed by Wiedemann, cannot be maintained any longer. Other causes may also provoke "luminescence:" the diamond glows after having been slightly heated, quartz after some rubbing, and gases when they are electrified. As to the many luminescent animals, such as the glow-worm, various marine animals and bacteria, we are not concerned with them now.

[22] Comptes Rendus of the Paris Academy of Sciences, February 10, 1896, vol. cxxii., p. 312.

[23] Ibid., cxxii., p. 386.

[24] Ibid., February, 24, 1896, vol. cxxii., p. 420. Further communications in the same and subsequent volumes.

[25] The literature of the subject is already immense. The main contributions to it will be found in Comptes Rendus, Philosophical Magazine, and Annalen der Physik. Excellent articles for the general reader appeared in Nature, June 14, 1900, and in Revue Generale des Sciences, January 30, 1899, by Mme. Sklodowska-Curie.

[26] In his first researches Becquerel thought that he had seen reflection and refraction of these rays; but now he has abandoned this idea (Comptes Rendus, 1899, vol. cxxviii., p. 771).

[27] This fundamental property of the Becquerel rays was announced on the very same day by Becquerel at Paris (Comptes Rendus, 1897, vol. cxxiv., p. 438) and by Lord Kelvin, J. C. Beattie, and Smoluchowski Smolan at Edinburgh, before the Edinburgh Royal Society (Nature, 1897, vol. xiv., p. 447).

[28] Comptes Rendus, 1899, vol. cxxvii., p. 1215.

[29] Ibid., 1900, vol. cxxx., p. 906.

[30] Proceedings of the Royal Society, May 10, 1900.

[31] Revue Generale des Sciences, September 30, 1900, gives a photograph of this spectrum.

[32] Annalen der Physik, 1900, 4th series, vol. ii., p. 742. Polonium gave no characteristic lines.

[33] Physikalische Zeitschrift, vol. .., 1900, p. 16.

[34] Comptes Rendus, 1896, vol. cxxiii., p. 49.

[35] Proceedings of the Royal Society, vol. lxi., p. 424. Bakerian lecture, delivered on March 24, 1898; Nature, April 28, vol. lvii., p. 607.

[36] Verhandlungen der deutschen physischen Gesellschaft, 1900, p. 5; summed up in Naturwissenschaftliche Rundschau, vol. xv., p. 103.

[37] Philosophical Magazine, 1899, vol. xlvii., p. 109; 1900, vol. xlix., pp. 1, 161.

[38] See E. Rutherford's paper in Philosophical Magazine, 1900, vol. xlix., p. 161; also Nature.

[39] A salt of uranium may be submitted to absolutely any chemical transformations, but when you return to the salt from which you started in your work, you find in it the very same electrical radio-activity which it had at the start. Impurities do not affect it. The radiation seems thus to belong to the molecule of uranium, and hardly to be influenced by external causes (Sklodowska-Curie, in Revue Generale, 1899, x., p. 47).

[40] Compare with Roberts-Austen's researches on the permeation of solid metals, mentioned in a previous "Recent Science" article.

[41] Thorium, 232.6; uranium, 239.6. Both belong to the twelfth and last series of Mendeleeff. The atomic weight of radium must be greater than 174 (Comptes Rendus, cxxxi., p. 382).

and that what we call life consists in a continual splitting up and rebuilding of these molecules. Are not the Becquerel radiations revealing to us that continual splitting and rebuilding of molecules which constitutes the life of both inorganic and organic matter? These are the grave questions which natural philosophers are brought to ask themselves, and which will certainly require many more patient researches.

(To be continued.)

ANATOMY AND PHYSIOLOGY OF INSECTS.*

INSECT PARASITISM—PARASITES OF INSECTS, MAN AND THE LOWER ANIMALS—ECONOMY OF PARASITISM.

WHAT is an insect? That seems very easy of answer; yet I doubt whether many people not especially versed in the subject could tell what an insect is, in the relation it bears to the other, lower, forms of life. One definition was lately given me by an individual: "An insect is a very small animal that has wings," which would just as well apply to a bat or a flying-fish. Insects belong to the arthropods, or the joint-footed animals, which include all the animals composed of rings, or segments. The insect body is composed of various rings. Another characteristic is that the body is segmented, or divided, into three parts—head, thorax and abdomen. In addition to that, an insect has a single pair of feelers, or antennæ as they are called. These simple characteristics serve to distinguish the insects from some of the other forms of life like the spiders and crustaceans, which have the head and thorax fused together. There are several pairs of antennæ usually, in the crustaceans—a feature readily distinguishing them from insects.

In addition to the above, insects breathe in a peculiar way, by what are called tracheæ, which are quite different from the organs of the higher orders of animals; that is to say, insects have no lungs. This division into three parts of the body and a single pair of antennæ would exclude the spiders, crabs and lobsters, shrimps, etc., which, when small, look very much like insects. These tracheæ, by which insects breathe, open out onto the side of the body, which is also quite different from the mouth-breathing in higher animals. The tracheæ open out into the sides of the body, into spiracles, through which the insect breathes. These spiracles, pass inward and ramify in all directions throughout the body. The crustacea breathe by gills, hence form a division of the arthropods, called branchiata, which word comes from branchia, which in reality means gills.

The insect body is divided into three portions—head, thorax and abdomen; while the crustacea and the spiders have the head and thorax fused together, or united, and designated by the term cephalo-thorax, distinct from which is the abdomen, the body being thus divided into two parts.

When insects attain the perfect state they have a single pair of antennæ, or feelers; and these are attached to the head. They have three pairs of legs, which are restricted to the thorax. This is another point in which illustrators, and those not specially interested in insects, frequently make a mistake. If you ask a person how many legs an insect has, very often he cannot tell you; or, if so, tells you incorrectly.

The body of an insect is made up of this series of rings or segments, within which are the vital apparatus and muscles. This is also a peculiarity of an insect in contradistinction to some of the higher forms of life. The hard part, or segments, or rings, are external; and all the vital organs are internal, which is entirely different, for instance, from such mammals as man, whose skeleton is supported by the bones, whereas the bones of the insect, you may say, are external. These joints of the insect (I do not mean the segments, but the joint) are more readily seen in the young. For instance, take the caterpillar; in this stage you have frequently noticed the ringed character of the young or caterpillar form of the butterfly. When they are hatched, the skin is soft and elastic and as they grow larger, they become harder in parts, there is a harder substance deposited; and when they become adult, of course the outside of the body is harder still, and this hardening is due to the deposition in the outer layer of the skin, or cuticle, of a horny substance called chitin, which is really analogous to bone in the higher orders of the animals, and forms the skeleton of the insect.

I hold in my hand the head of a very large beetle; and it will be noticed that you can put your finger right in this cavity that contained the soft parts, and this external skeleton supports the internal soft parts and is entirely different from some of the higher orders of animals having bones, where the soft parts surround the bones. This is very hard and tough, and gives a very good idea of this chitinous material that composes the external parts of all insects. Chitin is not deposited everywhere; it is deposited in rings, as it were, which gives you an idea of the segmented, or ring-like, or annulated character of the insect. For instance, here will be deposited this chitin, then in between will be a place where it is not deposited, and in that way the insect is enabled to move. Of course, if it were deposited everyhere, the insect would be rigid all over and would not be able to move. These spaces may be considered physiologically analogous to the joints between the bones in the higher animals.

These narrow rings of unaffected skin divide the segments from each other, and are termed sutures. In the larval condition, the sutures are usually wider than in the corresponding imagos. The sutures themselves often become hardened by chitin, so that the lines of division between two segments disappear. The head, in the larval condition, is divided up into a number of segments, but as they grow older, the segments unite because there is no necessity for much movement in the parts of the head of the imago. The only parts of the head that do move are the mouth parts and the antennæ.

The hardened parts of chitin are called sclerites; and the soft parts that remain between these portions (that is, the portions that do not become hardened, or chitinized) come under the name of suture, and these different parts form, and are technically called the body wall of the insect. The division of the insect-body into three distinct regions (the head, thorax and abdomen) should not be confounded with the division into segments, each region consisting of a number of segments. In the case of those insects undergoing a complete transformation (as the butterflies, bees and beetles) it is only the imago, or perfect insect, whose body shows clearly this division into three regions. For instance, take a caterpillar; you do not notice any division at all into three regions. It has a head and then the rest of the body is all one part.

Many of the segments of an insect's body bear varied jointed appendages, one pair to a segment. These appendages may be antennæ, jaws, legs, or claspers. The wings do not anatomically correspond, or are not homologous, to the appendages to which I have just referred. The head of the imago is usually distinct from the rest of the body. The segments are not easily distinguishable, owing to the sutures being more or less obliterated, and one might say, at sight, they consist of one segment. They are composed, however, of not one, but several, segments.

Insects have peculiar eyes. They have really two sets of eyes; the compound eyes and simple eyes. The compound eyes are composed of quite a number of facets, and they fit against each other like the cells of a honeycomb, for instance, and each facet is a cornea of a distinct, simple eye. The number of facets in the compound eyes of different insects varies from 50 to 30,000; so that insects should see well, but the probabilities are that they have a vision that is somewhat different from the vision of the higher animals, and they see in a way that is not possible, nor necessary, for us. They look upon minute objects, and in all probability the physiology of the eye is somewhat different when they have a compound eye composed of thirty thousand different parts.

The front part of the head bears the antennæ, or feelers, and these are joined appendages inserted on the pericranium between, or in front of, the eyes. The regular antennæ have joints of similar shapes; irregular antennæ have joints of dissimilar shape; then there are many intermediate forms. The structure of these feelers is extremely interesting, and very variable. I may briefly state that they are termed fusiform, filiform (thread-like), setiform (bristle-like), subulate (awl-shaped), moniliform (necklace-like), serrate (saw-like), pectinate (comb-like), pinnate (feather-like), lamellate (platelike), and so on. They have a great many interesting and curious shapes, and they are used in the systematic study and classification of insects.

The mouth parts differ very materially, and may be divided into two kinds—biting and sucking. They differ to such an extent in different insects that the great naturalist Fabricius founded a classification on these characters and their modifications, and these bear a direct relation to the character of the food. Some insects suck up the nectar, or honey, from flowers and some get their food by biting and have strong jaws. These two modifications, the biting and sucking parts, are the principal ones, and there are many different arrangements of these.

The thorax is divided into three parts (pro-thorax, meso-thorax and meta-thorax), and to it are usually attached three pairs of legs and two pairs of wings. The first segment, articulating with the occiput in front, is the pro-thorax, which bears the first pair of legs; the second segment is the meso-thorax, bearing the second pair of legs and the first pair of wings; the third segment is the meta-thorax, bearing the third pair of legs and the second pair of wings. The wings and the legs are further divided up into different parts, as in the higher forms of life.

Insects' wings are membraneous, and in many cases are covered with scales. This is particularly true of the butterfly and moth.

In regard to parasitic insects, "parasite" comes from a Greek word meaning "to feed on wheat or the grain." This does not give a very accurate definition of the term parasite. A parasite is an animal that feeds on, or in, or at the expense of another one, and in insects there are a great many of these. Of course, you know that insects feed upon plant-life (that is, a great many of them), and then another large proportion feed upon other insects—live upon their juices and live at their expense; and these are of great importance from the economic standpoint, because, if we can increase these parasits that destroy the injurious ones, if we know their habits and could rear them for this purpose, it would be a very important thing, so far as economic entomology is concerned, and we would have then two great destroying armies—one army destroying plant-life and the other destroying the first army. These parasites dwell in the bodies of their entertainers. They do not, as a rule, eat the structures of the insects upon which they live, but they live upon vegetable juices that the other insects take in with their food, and in many cases they have no organs to enable them to eat. They absorb lymph and blood from the hosts upon which they feed. When the host insect (or the insect that is being parasitized, or lived upon, by another) finds this out, it eats more voraciously, which is rather a suicidal tendency, because, if it ate less, it might have a chance of starving out its parasite.

Many insects have a great many parasites; for instance, one moth has sixty-three species of parasites that are known to feed upon it in various ways and forms. Then, in addition to primary parasites (or parasites proper), we have hyper-parasites (that is, parasites that live upon a parasite), and we may even have tertiary and quaternary cases of this parasitism. The eggs of parasites are often laid right in the body of the other insect upon which the young are destined to feed, and to enable them to do this, they have special organs, which are extremely interesting anatomically, known as ovipositors, and by the aid of these ovipositors the egg is conducted into the proper place. For instance, we have one common species that is parasitic on another insect that burrows in, and lives upon trees, and to reach the larvæ in the tree the parasite necessarily must have a long, penetrating organ to convey the egg into the tree where the other insect is feeding, and they are very peculiar and very interesting anatomically.

The egg may be laid inside the host, both the embryonic and post-embryonic development being gone through in the fluids of the host, and then there are various other methods of ovipositing, and sometimes the parasitic insect will drive its ovipositors right through the leaf to find a caterpillar on the other side. It seems to know it is there in some way, without actually seeing it; and then they know, in some way unknown to man, where to find the larvæ on which their young are destined to feed. We have one large species, as I have already mentioned, that deposits its eggs in a parasite that bores into trees; and they find these larvæ, upon which they live, with the greatest facility. Just how, we do not know, or do not understand.

It is necessary for man to study parasites for his own protection, not only in relation to himself, but in relation to lower animals, and in relation to economic entomology and plant-life. For instance, if he can find out the various parasites which live upon and destroy the plant-feeders, and rear them for that purpose, he would save a great deal in crops and in other things upon which insects live. This subject is of very great interest to the stock-breeder, the poultry-raiser and keepers of various animals for pleasure or profit. Even animals that are kept for pleasure (like horses, dogs, and cats) are very much distressed, often, by these parasitic diseases, and the lives of the lower animals are often destroyed in this way. The same general statement is true in regard to man. At one time the itch disease was very prevalent; it not only affected the peasant, but the king as well, and quite a number of personages prominent in history are known to have died from this disease. I remember one case recorded in a medical journal where seven million eggs and two million mites were said to exist in one individual of the human species. I suppose, of course, this was estimated by looking at the skin under the microscope. This disease (the itch) is caused by a parasite that burrows into the skin.

The parasites are divided into three divisions—parasites, messmates and mutualists. The parasites live upon the tissues of the host, the messmates take food collected by the host, and the mutualists ask protection and procure food in common, or eat offcast matter from the other insects with which they live. The parasites are divided into the arachnida, or spiders (these are not properly insects, however, but are considered under the head of insects); the mites, ticks, and animals of that class; the hymenoptera, the bees and wasps, some of which are parasitic; and the lepidoptera (for instance, the bee-moth, that is injurious to the honey-bee, is a parasite); and certain of the flies (like the horse-fly and the mosquitoes) may be said to be parasites in a way—annoying to man, at least. Certain of the bugs are parasitic. I have here, under that term, the kissing-bugs, and written after that I have "Nonsense;" and I may say here that there is no such thing as a kissing-bug, and the whole thing from beginning to end was a newspaper story which originated, I think, in Baltimore. I may have more to say about that when I come to one of the other lectures—"Insects in Relation to Disease."

The losses due to parasites are very great. For instance, two thousand five hundred goats died of a parasitic mite in a very short time. The ox-warble fly, affecting cattle and destroying their skins and affecting them in various ways, caused $3,000,000 loss in the Chicago Stock Yards in six months. Of course, there are various remedies for the parasites that affect man, but I will speak more particularly of those when I come to the subject of "Economic Entomology." The horse is the subject of various injurious parasites; for instance, the horse bot-fly (Gastrophilus equi), and this species has been known for a long time to farmers, stock men and veterinarians. The eggs are laid on the shoulders, forelegs, and under sides of the bodies of horses, and there held by a sticky fluid. The way the horse gets them into his alimentary canal is by licking them, and they are carried into the horse's mouth with the saliva, and, of course, sometimes they make them very ill and often kill the horses, when thousands of the bots, or young, of this fly may be seen fastened to the stomach of the horse.

Then there is another species of parasite belonging to the flies that is carried into the horse, largely in the same way, by the eggs being carried into the horse's mouth and then the young that hatch from these burrow right through the horse—through the œsophagus and the subcutaneous tissues along the back, come out and drop on the ground and then change into the chrysalis, and then the perfect insect emerges from the latter.

Then there are certain species affecting the sheep; among them, the sheep bot-fly, or maggot, that lives in the head and nostrils of the sheep; also certain flies, the larvæ of which sometimes get into the heads of human beings and kill them. Sometimes people sleep on the ground, and if they have catarrh, these flies will come and oviposit in the nasal cavities, and death sometimes results. A fly that you have frequently heard of, that does an immense amount of harm, is the tsetse (Glossina morsitans), found in Africa. This fly has done more to retard the civilization and the opening of Africa than any other one thing, because it very rapidly destroys beasts of burden, especially the horse.

In regard to distribution, at the different lectures I have mentioned different interesting collecting grounds, and have shown a few insects and a few slides in relation thereto. I have also mentioned some interesting features about the distribution of insects, and, as I told you, the insects are found practically everywhere; the extreme cold of the Arctic regions being no barrier to their range. For instance, in Greenland, insects are very abundant. Mosquitoes are extremely annoying in these northern climates. The butterflies and insects are small, as a rule, and obscure in color; but the individuals and numbers of one species are often very great, and

* A lecture delivered at the Academy of Natural Sciences of Philadelphia, by Henry Skinner, M.D., Conservator of the Entomological Section. Specially reported for the SCIENTIFIC AMERICAN SUPPLEMENT.

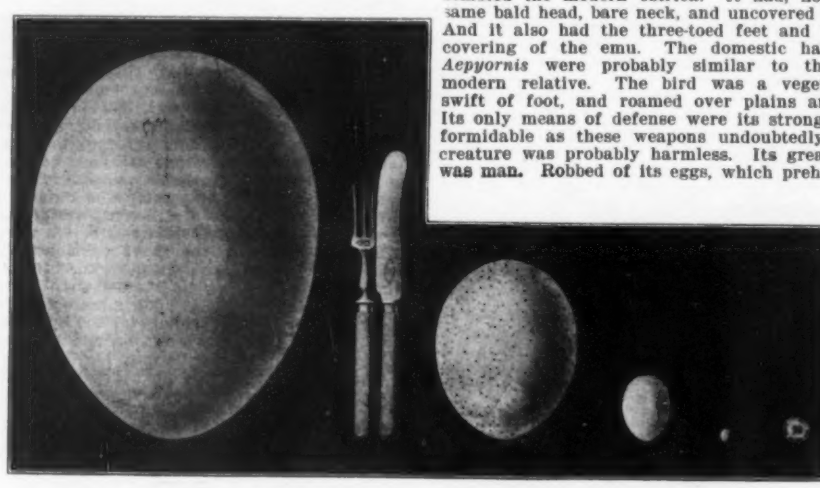
insects have been found with 580 miles of the Pole. Lieut. Peary collected flies and bees within 580 miles of the Pole. Greenland, while we often think of it as being covered with ice and snow all the time, will, if we stop to think of the name, Greenland, perhaps give us another idea of the place. In the northern parts of Greenland flowers are very abundant, and there is considerable vegetation of a low growth. For instance, there are trees there that you can sit on, and put in your pocket, with the greatest facility. Some of the butterflies found in Greenland

THE EGGS OF AN AEPYORNIS, AN OSTRICH, AND A HEN COMPARED.

are represented here. They expand perhaps 1½ or 2 inches; and, in addition to these, there are butterflies like the common yellow butterflies that we see so frequently in the wet places along roads. Here is a species that is found in Greenland—Argynnis arctica, also Argynnis polaris. Insects and butterflies are found very high up on the mountains. Some years ago Prof. Heilprin found butterflies on the summit of the volcano of Iztaccihuatl, fifteen thousand feet above sea-level, in Mexico.

PREHISTORIC OSTRICHES.

THE ostrich, now regarded as the largest of all feathered creatures, is a descendant of a genus of birds which in prehistoric times attained an enormous size. In the alluvial deposits of which the more recent strata of Madagascar are composed evidence enough has been found to show that ostriches fourteen and fifteen feet in height once lived on the island. These birds of the genus *Aepyornis* occupy a position between the emus (*Dromaridae*) and the ostriches (*Struthionidae*), and resemble cassowaries (*Casuaridae*) in certain respects. From the bones which have been found, three different species of *Aepyornis* can be distinguished. In the lowlands and particularly along the southern coast of Madagascar the remains of the two larger species (*Aepyornis maximus*, Geoffroy, and *Aepyornis medius*, Milne-Edwards) were first found. In 1880 the indefatigable explorer Hildebrandt penetrated into the central portion of the island and there discovered in the Ankaraa hills near Sirabé the third variety, which has accordingly been named *Aepyornis Hildebrandti*. This third species is about five feet in height.



COMPARISON OF AEPYORNIS, OSTRICH, HEN, AND WREN EGGS.

The scientific world would probably know nothing of the existence of these gigantic birds if the curiosity of travelers had not been aroused by pieces of huge eggshells which were thrown up now and then by the spade. Abardie, the captain of a small French sailing-vessel, hardly believed his eyes when he saw his first *Aepyornis* egg in 1850. The natives had broken away the top and used the shell as a vessel. Abardie immediately bought the egg and offered a reward for a perfect shell. His efforts were successful; for the natives soon brought him a whole egg, found in the dry bed of a river. Later he received a few bones of the bird, likewise found in the bed of a stream.

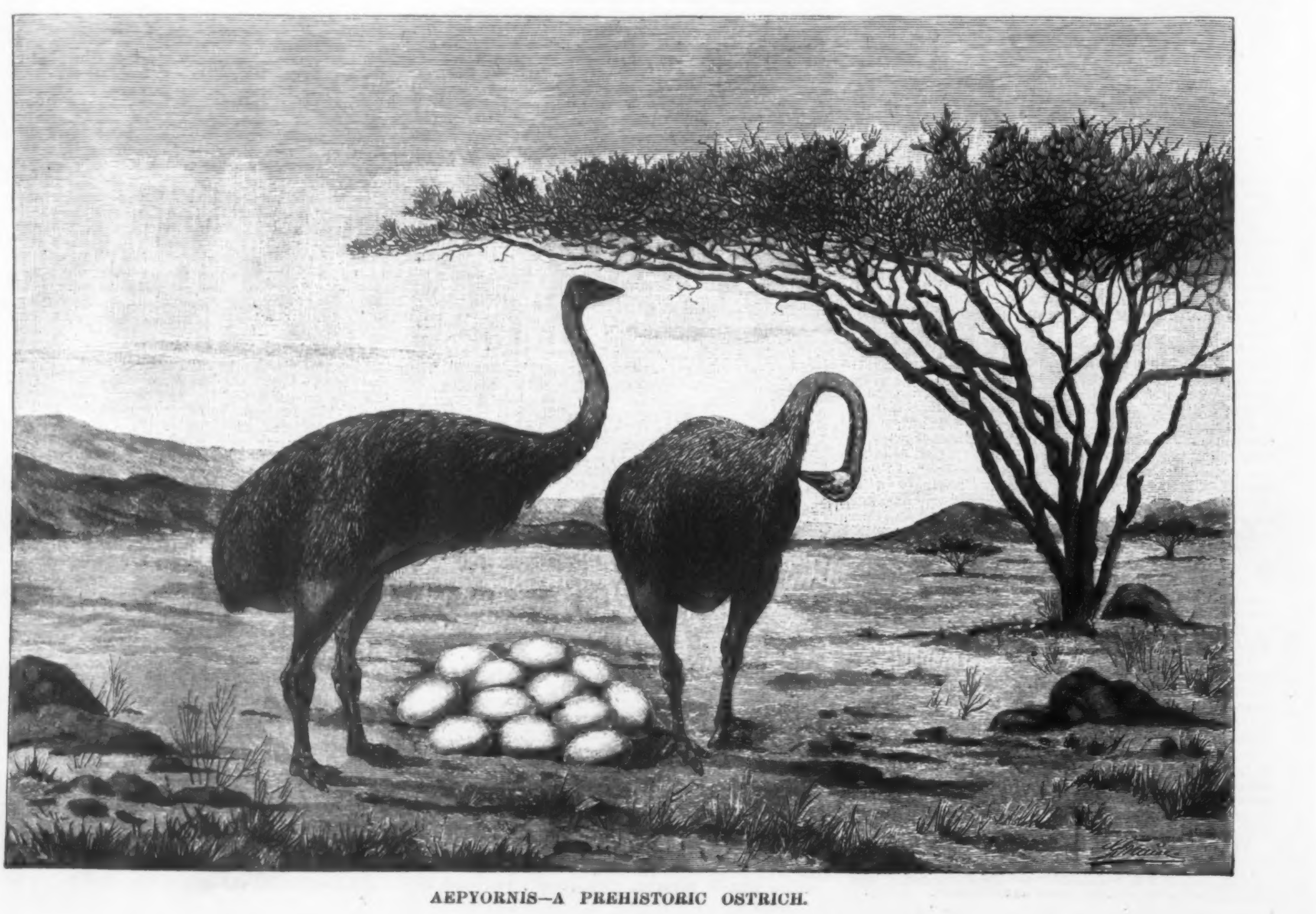
These were the first remains discovered. Since Abardie's time many more eggs have been found, but very few bones. In the national museums of Europe and in various private collections there are not more than twenty-two well-preserved *Aepyornis* eggs, of which seven are owned by the Musée d'Histoire Naturelle of Paris. These relics of prehistoric times have been purchased for sums varying from $450 to $6,000.

The extraordinary size of an *Aepyornis* egg is graphically shown in one of our illustrations, taken from the Illustrirte Zeitung. A rather fair-sized shell is about 7 times larger than an ostrich egg, 184 3-5 times larger than a hen's egg, 20,308 times larger than a wren's egg. Such an enormous egg would offer ample food for sixty persons.

The bird that laid these huge eggs is shown in the second of our illustrations. Although practically nothing is known of the plumage of the *Aepyornis*, or, indeed, anything of its general appearance, it is possible to present a fairly accurate picture from the bones which have been found. The creature probably resembled the modern ostrich. It had, no doubt, the same bald head, bare neck, and uncovered extremities. And it also had the three-toed feet and hairy body-covering of the emu. The domestic habits of the *Aepyornis* were probably similar to those of its modern relative. The bird was a vegetarian, was swift of foot, and roamed over plains and prairies. Its only means of defense were its strong legs. But formidable as these weapons undoubtedly were, the creature was probably harmless. Its greatest enemy was man. Robbed of its eggs, which prehistoric man probably found of no little service as vessels and as food, it is small wonder that *Aepyornis* is now extinct.

VOCATIONS OF WOMEN IN GERMANY.

IN the census of June 14, 1895, the total number of females in Germany were returned at 26,361,123. Of these, inclusive of domestic servants, there were 6,578,850 earning wages, i. e., 24.96 per cent of the entire female population. If the age of 10 to 70 is calculated only, the young children and aged women are excluded, 34.1 per cent females are engaged in work, as against 38.3 per cent in Switzerland, 64.1 per cent in Austria, 50 per cent in Italy, 36.4 per



AEPYORNIS—A PREHISTORIC OSTRICH.

cent in the United Kingdom, and 17.5 per cent in the United States; 2,381,175 females are engaged in agriculture and horticulture, i. e., one-third of the total; in trade and industry, 354,686; in the clothing and cleaning industries, 299,250; in hotels and restaurants, 213,679; in commercial undertakings, 144,938; in the industries of food and consumption, 125,190, etc. According to H. M. Consul-General at Frankfort-on-Main, the shifting in the direction of the increase of wage-earning married women since the last census of 1882 is very remarkable. Out of 10,000 wage-earning females there were in 1895, 2,155 married and 7,845 single, as against 1,726 married and 8,274 single in 1882. The number of married women among working women has been increased surprisingly, indeed by 25 per cent in the case of actual working women, and if servant girls are included, even by 48.12 per cent. This state of things cannot be looked upon as sound. Figures for the last few years, which with this great industrial rise brought a very keen demand for work, are not yet made up; but in independent vocations the female element is gradually gaining admission. The endeavors made during several years to gain for women access to the higher vocations have met with success in the past year. In the first instance, so-called "Gymnasia (colleges) for Girls" were organized in Berlin, Leipzig, Karlsruhe, Stuttgart, Konigsberg, Hanover, etc., in which girls are to be prepared for studying at a university. In the session of the Imperial Diet of January 21, 1898, the Prussian Minister Count von Posadowsky, declared that a convention was to be concluded between the Federal Governments, according to which lady students who as visitors at the universities had obtained the necessary training were to be admitted to the medical, pharmaceutical, and dental examinations. On April 21 the General Council passed a resolution to that effect. The movement for the emancipation of women has thereby obtained a great and important success. As regards the medical profession, there still reigns freedom in Germany; it may be exercised without the approbation of the government, but the adoption of a title or a degree not granted by German universities is not allowed when an impression might be given that it referred to one granted by German universities. A female medical or dental practitioner has had hitherto to study abroad, but can now do so at home, and can pass an examination for State approbation in the same manner as male practitioners. Up till very recently there were only 40 lady dentists in Germany, but many so-called "lady practitioners." There are, indeed, only nine lady physicians in Germany, as against 700 in Russia, and 5,000 in America. Now that the course of study is open to women the proportion will soon be changed. A woman could, so far, not be employed in a drug store in Germany, nor was she allowed to exercise her rights if she became the proprietor of a drug store by inheritance.—Journal of the Society of Arts.

RIGHTS OF MOTOR VEHICLES.

THE question as to the rights of a motor vehicle on a public highway was raised in the Bergen County Court at Hackensack, N. J., recently, and Justice Jonathan Dixon, of the New Jersey Supreme Court, in charging the jury, interpreted the law bearing upon the issue raised, says The Electrical World. As the question depends not upon the construction of statutes, but upon the application of principles of common law, the justice's analysis applies with equal force in this State.

The suit was for damages for the death of Mrs. John L. Guyre, who died from injuries received by being thrown out of her carriage at Midland Park, N. J., her horse having taken fright at a motor vehicle operated by Dr. William L. Vroom. After taking 23 ballots the jury reported its inability to agree upon a verdict.

The prosecution having made the contention that the motor vehicle was a nuisance and had no rights upon a public highway, Justice Dixon charged as follows:

"The question is whether the machine driving along the country roads without a horse in front and discharging steam behind is so likely to frighten a horse on the highway and thus endanger the road as to constitute the machine a nuisance. It is argued that it is an improved method of locomotion, but it does not follow that it is to be tolerated. The right to drive horses along the highway is an established right, a common right, and if a modern method of locomotion is used of such a nature that it commonly brings discomfort and danger to those exercising the common right, the established right of travel on highway, then it is a nuisance and cannot be tolerated. But it does not follow it is a nuisance because it occasionally or exceptionally frightens horses. That would not make it a nuisance. In order to make it a nuisance its common effect must be to substantially interfere with the people who drive horses along the highway. Is it of such a nature that it is so likely to frighten horses and thus endanger travelers on the highway as to make it a nuisance, or is it only its exceptional effect? If it is its common effect, then it is a nuisance; if exceptional effect, it is not a nuisance. If this method of locomotion is a common nuisance, and was the approximate cause of death, then the defendant is responsible."

MILITARY TESTS OF AUTOMOBILES IN 1900.

ALTHOUGH the year 1900 did not, as the public in general expected, give us the ideal low-priced small carriage, it will at least be prominent in the annals of automobilism on account of the first practical applications that were made of the new locomotion.

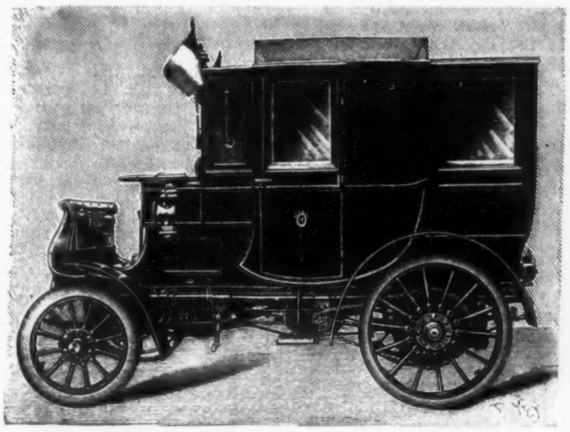


FIG. 1.—AUTOMOBILE COUPÉ FOR A GENERAL.

Of these there is none more interesting than that of mechanical vehicles to the service of armies; and experiments at the great maneuvers of this year have definitely classified the automobile among the indispensable instruments of war. The mechanical vehicles utilized belonged to different categories.

I.—The commander-in-chief of the great maneuvers had at his disposal 6 extra-rapid carriages of the Mors and Panhard-Levassor systems, 3 voiturettes and 11 motocycles, which were distributed as follows: (1) To the general commander-in-chief, 3 twelve-horse carriages, 3 motocycles, and 3 voiturettes, among which it is well to mention a small searchlight carriage of the Renault system provided with a special gearing permitting the motor to actuate either the driving wheels or a small lighting dynamo placed in the rear of the vehicle; (2) to the general, chief of staff, 1 sixteen-horse carriage and 2 motocycles; (3) to the general commanding the Army of the North, 1 twelve-horse carriage and 3 motocycles; (4) to the general commanding the Army of the South, 1 Mors carriage of 22 horse power and 3 motocycles.

II.—The services of the rear were assured in each army by 1 Scotte steam train of the Versailles engineer corps; 1 De Dion-Bouton steam truck; 1 Panhard-Levassor 8 horse power truck, and 1 De Deitrich 9 horse power truck. These two latter vehicles, which were gasoline ones, were placed at the service of the cavalry.

III.—The foreign military attaches were carried upon the field of battle by means of several automobiles, among which it is well to mention a De Dion-Bouton steam brake of 20 horse power, provided with pneumatic tires, 1 Panhard-Levassor 12 horse power omnibus, and 1 large De Deitrich brake, accommodating 6 passengers. The new mode of locomotion was highly appreciated by the representatives of foreign powers.

The tests of automobile conveyances had, moreover, another result, that of permitting of obtaining precise data as to the operation and net cost of war automobiles. Fortunately for French manufacturers, the weather was particularly favorable last September, and this permitted of obtaining very remarkable figures. Finally, the same maneuvers were taken advantage of for experimenting with the different systems of hauling baggage wagons. One of the haulers, due to Col. Renaud, permitted the vehicles to follow its direction in turnings, while at the same time preventing any lateral displacement. This system, moreover, permits of substituting animal for mechanical traction in an instant.

Finally, to complete this rapid review, let us mention the fact that at the Exposition of the Armies of the Land and Sea, the automobile industry was brilliantly represented by different types of vehicles, the carriage-work of the majority of which had been very carefully studied by MM. Kellner & Sons.

These vehicles were as follows: (1) De Dion-Bouton motocycle for the service of the staff office; (2) Decauville voiturette, model of 1900, with bottle-case in the rear; (3) a Mors 16 horse power vehicle for generals; (4) a 12 horse power Panhard-Levassor omnibus for the conveyance of army staffs; (5) an army staff carriage of the Peugeot system, comprising a central coupé designed for the general, and a small two-passenger omnibus in the rear for the use of his officers or secretaries (Fig. 1); (6) a surgeon's carriage—an army corps ambulance carrying 12 hampers for dressings and all the other operating material necessary (Figs. 2 and 3); (7) postal telegraph carriage mounted upon a Mors frame; (8) large Koch van for campaign telegraphic material, as well as for passenger pigeons; and (9) a small van for the army postal and treasury service.

Finally, the heavy weights were represented at the Champ de Mars and Vincennes by the various very well-known types of Scotte haulers and De Dion-Bouton trucks.—La Nature.

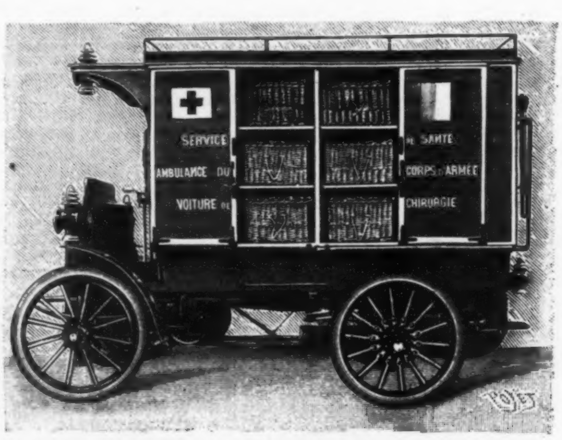


FIG. 2.—AUTOMOBILE SURGERY CARRIAGE (OPEN).

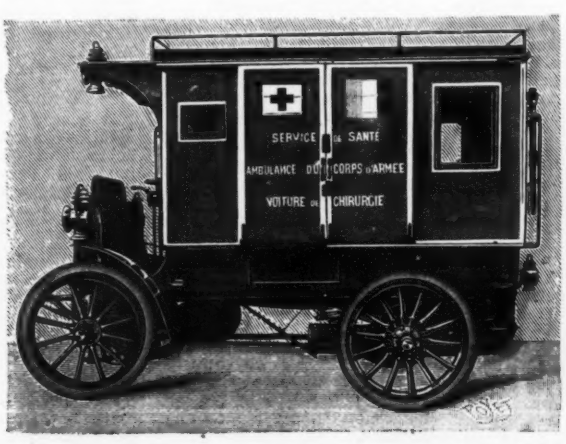


FIG. 3.—AUTOMOBILE SURGERY CARRIAGE (CLOSED).

HOW AMERICAN PRACTICE DIFFERS FROM EUROPEAN REGARDING FINISH.

ONE point which strikes the American observer of European engines, especially of the engines of Continental Europe, is their finish. Visitors to the World's Fair at Chicago in 1893 had an example of this in the 1,000 horse power vertical triple exhibited by a Prussian builder. With its bright parts finished by an honest application of the polishing tool, instead of being covered with a coat of cheap nickel or paint, it attracted universal attention as an example of mechanical æsthetics. In the engine rooms of Continental Europe, as well as at the Exposition, the same thing is found. The frames, instead of being painted in bright colors, with gilded stripes and decalcomanie, are in sober slate color or black, rubbed to a smooth but not shiny finish. Where columns are used, as in some of the verticals, they are polished like a piece of new shafting. All the little work about the valve gear, etc., is finished as finely as though it were part of a scientific instrument, and the laggings are almost universally in sheet metal, nicely finished in the natural color.

These things cost money. In one engine room, where quadruple expansion engines built by a German manufacturer were running alongside a triple expansion engine built by an American company, we were told that they could buy three horse power of the American engine for what two horse power of the German machine cost, both set up. There was very little difference in the steam required per horse power. The American machines were such as are seen in the ordinary American power station—good, businesslike affairs, but not

particularly ornamental; the others were models of mechanical elegance.

How far does it pay to go in this direction? There are those who would spend all the allowable cost of an engine in insuring integrity of the material and the working fits. They would have the best of material, they would have scraped wearing surfaces and ground pins in hardened steel bushings, not a dollar would they spare where it could be expended to prolong the life, insure the safety or increase the efficiency of the machine, but they draw the line when it comes to expending money for purposes of mere ornamentation. Yet in nothing else do they insist upon this severe utilitarianism. In their costumes, in their homes, in their offices even, you will find a concession to the universal desire to be surrounded by the fitting, the appropriate and the beautiful. The ordinary man does not, however, go to business in broadcloth, place a Persian rug beneath his desk and hang his office walls with expensive paintings. We can admire the mechanical perfection and beauty of the European work, it may furnish us examples for show plants and exceptional installations, but the ordinary work-a-day finish of the best American machines is probably all that the American power user will care to pay for.—Power.

RHODIUM ALLOYS.

A SPECIMEN piece of pure rhodium wire, exhibited by Heraeus, of Hanau, at Paris, indicates that this metal has only quite recently been prepared in sufficient quantities to study its metallurgical character, although platinum-rhodium thermocouples have been used for several years. Great attention is now being paid to the nature of alloys, and the rhodium alloys are not less interesting than others, says Engineering. According to Dr. Rössler, of the Gold and Silver Refinery of Frankfort-on-the-Main, rhodium appears to have been confused with iridium in some cases. We have two groups of platinum metals, the one with a specific gravity of about 12, the other with a gravity of about 22. Rhodium belongs to the first group, iridium to the second. If 5 milligrammes of rhodium are fused with 1 gramme of silver, melted in lead, the regulus resulting from cupellation is not bright as silver, but dim gray. When the grain is dissolved in nitric acid, this gray film disintegrates into fine, glittering scales which float in the solution. These scales are fine hexagonal crystals of pure rhodium. When more rhodium is applied, it is afterward reobtained in the amorphous state. There is, therefore, no alloy of rhodium and silver, and rhodium is not soluble in silver, but it is soluble in lead. Iridium behaves similarly. The silver-iridium grain, resulting when the above-mentioned proportions are observed, has the bright color of silver, the much heavier iridium particles are imbedded in the bottom of the grain, and when nitric acid is applied as solvent, the iridium is again found crystallized, but the crystals rapidly sink in the solution. Larger proportions of iridium are not dissolved by the silver, and remain amorphous. On continued heating, the iridium becomes oxidized. The case is quite different with silver and platinum. These two metals alloy, and when such an alloy containing only a small proportion of platinum is dissolved in nitric acid, some of the platinum, which is itself insoluble in nitric acid, passes into solution with the excess of silver. Further, the platinum residue proves oxidized, and is then soluble in hydrochloric acid. Thus, an observation of Von der Ropp's is confirmed, and it has, in fact, been known that the anode mud, obtained in silver refineries from silver containing both gold and platinum, on the Moebius process, leaves an oxidized platinum residue behind, soluble in hydrochloric acid. Ropp found water, oxygen, and nitrous acid in this residue. The rhodium gold alloy resembles this platinum silver in these respects. It is prepared like the rhodium silver alloy, and dissolves in aqua regia with a darker color than gold alone would give. The properties of rhodium are evidently influenced by a large excess of gold. If more rhodium (above 5 per cent.) is forced into the gold, which requires long-continued fusion, the excess of rhodium is afterward found in beautiful star-shaped or feathery needles, easily distinguished from the gold by their gray color. Gold and rhodium seem to form a real alloy, but it has not been isolated so far. To investigate the question further, Rössler prepared alloys of rhodium with bismuth, tin, and antimony. The metals have to be heated above their melting points for some time. Bismuth takes up 5 per cent. maximum of rhodium. When the excess of bismuth is extracted with cold nitric acid, crystals of Rh Bi, remain behind, which are themselves soluble in boiling nitric acid. The same crystals can be prepared by fusing together the respective proportions of the two metals corresponding to that formula, and those crystals are entirely soluble in hot nitric acid; no bismuth can then be extracted with cold acid. Any excess of rhodium is afterward found in the crystallized or in the amorphous state; the amorphous metal had evidently not been taken up by the fused mass.

VIOLET PERFUMES.

IONONE is an artificial perfume which smells exactly like fresh violets, and is therefore an extremely important product. Although before it was discovered, says the Seifensieder, compositions were known which gave fair imitations of the violet perfume, they were wanting in the characteristic twang which distinguishes all violet preparations. Ionone has even the curious property possessed by violets of losing the scent occasionally for a short time. It occasionally happens that an observer, on taking the stopper out of a bottle of ionone, perceives no special odor, but a few seconds after the stopper has been put back in the bottle, the whole room begins to smell of fresh violets. It seems to be a question of dilution. It is impossible, however, to make a usable extract by mere dilution of a 10 per cent. solution of ionone. Other things must be used, as seen in the recipes at the close of this article.

It is advisable to make these preparations in somewhat large quantities, say, 15 to 20 kilos at a time. This enables them to be stocked for some time, whereby they improve greatly. When all the ingredients are mixed, ten days or a fortnight, with frequent shakings, should elapse before the stuff is filtered. The filtered product must be kept in well-filled and well-corked bottles in a dry, dark, cool place, such as a well-ventilated cellar. After staying here for five or six weeks the preparation is ready for use. It is also true of infusions, such as those of orris, musk, benjamin, tolu, styrax, etc., that they improve with age, and they should therefore be made in good quantities, and a long time before they are wanted. This is specially the case with musk.

In making milled violet soaps ionone can be used to advantage with orris oil, but such a method of perfuming is too expensive to be extensively employed in practice. Iraldeïne is cheaper than ionone, and can hence be used in the necessary quantities. With the oils of orris and bergamot it gives a splendid violet perfume. The soaps keep the odor perfectly in stock. The best oil for the soap is palm oil.

Violet (Quadruple Extract).

Jasmine Extract, 1st pomade	100	grammes.
Rose Extract, 1st pomade	100	"
Cassia Extract, 1st pomade	200	"
Violet Extract, 1st pomade	200	"
Oil of geranium, Spanish	2	"
Solution of vanillin, 10 per cent	10	"
Solution of orris, 10 per cent	100	"
Solution of ionone, 10 per cent	20	"
Infusion of musk	10	"
Infusion of orris from coarsely ground root	260	"

Violet (Triple Extract).

Cassia Extract, 2nd pomade	100	grammes
Violet Extract, 2nd pomade	300	"
Jasmine Extract, 2nd pomade	100	"
Rose Extract, 2nd pomade	100	"
Oil of geranium, African	1	"
Ionone, 10 per cent	15	"
Solution of vanillin, 10 per cent	5	"
Infusion of orris from coarse ground root	270	"
Infusion of musk	10	"

Violet (Double Extract).

Cassia Extract, 2nd pomade	100	grammes
Violet Extract, 2nd pomade	150	"
Jasmine Extract, 2nd pomade	100	"
Rose Extract, 2nd pomade	100	"
Oil of geranium, Reunion	2	"
Ionone, 10 per cent	10	"
Solution of vanillin, 10 per cent	10	"
Infusion of ambrette	20	"
Infusion of orris from coarse ground root	300	"
Spirit	210	"

Violet (Simple Extract).

Cassia Extract, 2nd pomade	50	grammes
Violet Extract, 2nd pomade	100	"
Jasmine Extract, 2nd pomade	50	"
Rose Extract, 2nd pomade	50	"
Oil of geranium, Reunion	5	"
Oil of bergamot	5	"
Ionone, 10 per cent	5	"
Solution of vanillin, 10 per cent	5	"
Infusion of ambrette	50	"
Infusion of orris from coarse ground root	400	"
Spirit	280	"

Dye with tincture of chlorophyl.

Violet Toilet Water.

Solution of orris, 1 per cent	400	grammes
Solution of vanillin, 10 per cent	125	"
Ionone, 10 per cent	50	"
Infusion of musk	75	"
Infusion of orris	2,350	"
Spirit	14,000	"
Orange flower water	4,000	"
Distilled water	4,000	"

Violet Head Water, Frothing.

Solution of orris, 1 per cent	500	grammes
Solution of vanillin, 10 per cent	150	"
Ionone, 10 per cent	100	"
Infusion of musk	50	"
Infusion of orris from coarse ground root	1,950	"
Spirit	12,000	"
Distilled water	10,000	"
Pure glycerine	175	"
Pure carbonate of potash	50	"
Pure soft soap	25	"

Dye with tincture of chlorophyl.

Violet Powder.

Rice powder	500	grammes
Talc powder	700	"
Orris powder	300	"
Magnesia carbonate	500	"
Violet (Quadruple Extract)	75-100	"

Mix the powders thoroughly first. Then add the perfume and rub through a gauze sieve.

Violet Sachet Powder.

Rose leaves	350	grammes
Sumatra benjamin powder	100	"
Orris powder	550	"
Infusion of musk	30	"
Ionone, 10 per cent	3	"
Orris oil	2	"
Bergamot oil	5	"

AUTOMOBILE FIRE-ENGINE DRILL.

PARISIAN firemen recently gave a successful drill with automobile fire-engine apparatus of an improved character, all three types of machines used having been previously exploited in the drill at Vincennes. The apparatus consisted of an electrical hose-wagon, with a capacity of six men, life-saving tackle, ladders, and the usual hose-reel, and an electric fire pump of an entirely new type consisting of a metallic tank of 100 gallons capacity, mounted on an automobile carriage, with pump, hose, and nozzle. The apparatus for pumping the water is operated by the same motor which drives the engine, which, on arrival at the fire, is switched off to the pump, thus serving a double purpose. The hose is wound on a cylindrical reel, so fixed that, on arriving at a fire, the stream is immediately available and the capacity of the tank is exhausted while the hose from the hose-cart is being attached to the water main. The engine weighs, in running order, with its crew and a full tank, a trifle over three tons. The apparatus on both engine and hose-wagon is so constructed that part of the energy generated may be used for the lighting of the arc and incandescent lamps during night fires. The third vehicle is an electrical ladder. This is mounted upon a low truck, upon which the large ladder used by the Department is hoisted almost horizontally by means of an inclined plane, to the perpendicular, the weight of the apparatus, including the crew, being over four tons and a half, or the heaviest of all the fire machinery to which mechanical propulsion has been applied.

DETERMINING FREE ALKALI IN SOAP.

By R. E. DIVINE.

THE usual method of making this determination prescribes a separation of caustic from carbonated alkali by drying the soap, dissolving in absolute alcohol, and after filtering and washing the undissolved carbonate with alcohol and dissolving in water to titrate the solutions containing caustic and carbonate, respectively, with standard acid. This method is open to several objections, aside from the amount of time consumed. If it is desired to obtain accurate results on the caustic and carbonate separately, the preliminary drying of the soap introduces an error, since the caustic alkali will take up carbon dioxide from the air unless the drying is done out of contact with air. It is quite a troublesome process to filter an alcoholic soap solution if one is not provided with appliances to keep the funnel hot during filtration. Dudley and Pease use an alcoholic solution of stearic acid for titrating the caustic, but still filter from undissolved carbonate, and determine the latter in the usual manner. In the following process the writer has succeeded in eliminating filtration. For this method it is necessary to provide three standard solutions:

1. Hydrochloric acid, N/10 (for standardizing 2).
2. Caustic soda, N/10, in alcohol.
3. Stearic acid, N/10, in alcohol.

2 and 3 should be exactly equivalent one to the other, titrated warm with phenolphthalein indicator.

Two grams soap (which needs no drying) is weighed into a round-bottomed flask, of about 300 cc. capacity, and 50 cc. alcohol poured upon it. N/10 stearic acid is now run in from a burette in amount judged to be sufficient to neutralize the free alkali in 2 grams of the soap, some phenolphthalein added, and the flask then stoppered with a cork stopper, through which passes a glass tube about 30 inches long and of about ¼ inch internal diameter, the lower end ground to a point on a grindstone, and the purpose of which is to serve as a reflux condenser. The flask and contents are placed on a steam-bath and heated thirty minutes, at the expiration of which time the solution should be quite clear and show no alkali with the phenolphthalein. If the solution turns red during the boiling, showing that an insufficient quantity of stearic acid has been added at first, add more of that solution until the color disappears, then several cubic centimeters in excess and heat twenty minutes further. The flask is now removed from the bath, and, after a few minutes cooling, titrated with N/10 caustic soda. The difference between the number of cubic centimeters stearic acid solution added and the number of cubic centimeters caustic soda used to back titrate is equivalent to the total free alkali present.

While the first flask is heating, weigh out in a similar flask 2 grams of soap and add 50 cc. alcohol, and place on the steam-bath. When the first test is finished, calculate roughly the total alkali, assuming the total quantity to be carbonate. Now add to the second flask an amount of 10 per cent. barium chloride solution sufficient to precipitate alkali found, heat a few minutes, add phenolphthalein, and titrate with N/10 stearic acid. The titration must take place slowly and with thorough agitation of the liquid for the reason that the sodium or potassium hydroxide reacts with the barium chloride added and forms sodium chloride and barium hydroxide. The latter is not very soluble in the alcoholic liquid, and sufficient time and pains must be taken to insure its complete neutralization by the stearic acid. A blank test should be made on 50 cc. of the alcohol, since this frequently contains carbon dioxide, and the number of tenths cc. N/10 caustic soda necessary to neutralize the free acid in this quantity of alcohol added to the reading of the stearic acid burette in the second test. This corrected reading gives the number of cubic centimeters N/10 stearic acid used to neutralize the caustic alkali in 2 grams of soap. The difference between the total alkali found and the caustic will, of course, give the carbonate. For example: 2 grams of soap and 15 cc. N/10 stearic acid; run in 3.2 cc. N/10 caustic soda to back titrate. Consequently, 15—3.2 equals 11.8 cc. N/10 stearic acid equivalent to total free alkali.

To neutralize the caustic in the sample treated with barium chloride was required 4.1 cc. N/10 stearic acid. Fifty cc. of the alcohol used required 0.2 cc. N/10 caustic soda, then 4.1 add 0.2.

4.3 cc. N/10 stearic acid to neutralize free caustic alkali. 11.8—4.3 equals 7.5 cc. N/10 stearic acid to neutralize carbonated alkali.

1 cc. N/10 stearic acid equals 0.004 gram caustic soda or 0.0053 gram sodium carbonate.

The above figures calculated to percentage would be: 0.86 per cent. caustic soda and 1.99 per cent. sodium carbonate.

It is to be noted that a rubber stopper cannot be used in the flasks for dissolving the soap on account of the sulphur in the rubber, which decolorizes an al-

coholic solution of phenolphthalein. The method is applicable to all soaps which do not contain fillers which react with the standard solutions employed.—Oils, Colours and Drysalteries.

[Continued from SUPPLEMENT, No. 1307, page 20956.]

THE STEAM TURBINE: THE STEAM ENGINE OF MAXIMUM SIMPLICITY AND OF HIGHEST THERMAL EFFICIENCY.*

By ROBERT H. THURSTON.

THE Laval turbine, the modernized simple form of the Branca wheel of 1629, was brought out by its inventor about 1886, and at once took its place in the field of engineering to which this class of motors is best adapted. It became well known to the profession in the United States through its admirable presentation at the Columbian Exposition, at Chicago, in 1893. In 1896, it was stated that there had already been supplied to users about 23,000 horse power of this type. It was rapidly developed for high-pressure steam, and in 1898, the following table of consumption of dry steam per unit of time and power was published by the continental European representatives of "La Société des Turbines à vapeur de Laval."

Since the date of publication of this table, the steam pressure has been carried up into the thousands of pounds per square inch, one to two hundred atmospheres, and the consumption of steam and of heat and fuel per unit of time and power still further reduced. In the table, it is to be here particularly noted that the expenditure of steam is reduced over one-third by condensation, as compared with non-condensation, at all points in the table.

Tests of the 10 horse power Laval turbine of Sibley College, with two, three, and four jets in use, by Messrs. Whitfield and Wilson, 1896, gave the following tabulated results. The generator attached is rated at 6.6 kilowatts output at full load. The turbine disk is 5 19-32 inches diameter, the vanes ⅜ inch wide, the rim 1-16 inch in thickness, and the rated speed 24,000 revolutions per minute. This gives 656 feet per second, 39,360 feet per minute; about 7½ miles a minute, 450 miles an hour.

The turbine is geared to the generator by a reducing gearing having the ratio 10 to 1, giving the generator

CONSUMPTION OF DRY STEAM PER EFFECTIVE HIGH PRESSURE PER HOUR.

H. P.	Admission pressure of that turbine in kilos par cm^2					
	6	8	10	12	16	20
	1.—*Escape to the air. Kg.*					
3	26.35	24.2	23.—	21.8	20.6	20.0
5	22.7	21.0	19.75	18.9	17.9	17.4
10	22.7	21.0	19.75	18.9	17.9	17.4
15	21.4	19.7	18.6	17.8	16.8	16.25
20	20.9	19.2	18.1	17.4	16.4	15 8
30	19.9	18.3	17.2	16.4	15.4	14.9
50	18.5	17.0	16.0	15.2	14.1	13.4
75	17.5	16.1	15.05	14.3	13.3	12.65
100 and 150.	17.5	16.0	15.0	13.95	13.25	12.55
200	16.5	15.0	14.5	13.75	12.8	12.0
300	16.25	14.5	13.75	13.0	12.0	11.50
	2.—*Escape to the condenser. Vacuum* 64 *cm. Kg.*					
3	18.0	17.3	16.6	16.2	15.6	14.9
5	16.3	15.75	15.3	14.95	14.4	13.8
10	14.1	13.55	13.1	12.6	12.25	11.9
15	13.55	13.0	12.6	12.25	11.8	11.45
20	11.6	11.1	10.9	10.45	10.0	9.7
30	11.6	11.1	10.75	10.45	10.0	9.7
50	10.3	9.8	9.45	9.2	8.85	8.65
75	10.3	9.8	9.45	9.2	8.85	8.65
100	10.2	9.1	8.75	8.5	8.2	7.9
200	8.8	8.4	8.0	7.8	7:6	7.4
300	8.6	8.25	7 75	7.6	7.4	7.2

a speed of 2,400 revolutions per minute. Copious lubrication was insured by the use of "sight-feed" oil cups. The vacuum was about 16 inches, except in the later runs, when it was purposely reduced to 1.3 inch at the condenser. The steam was saturated and carried some moisture. The turbine showed as good work as could have been expected from the reciprocating engine of similar capacity, and is probably capable of still better work when the form of nozzle can be perfectly identified for any stated conditions of operation, as the jet should have a specific character for each set of conditions of operation. Its "water-rate" of 46.8 pounds per horse power hour is much better, in fact, than is usually obtained with the common engine of equal power. The best work is performed with two nozzles.

The same turbine, in a series of tests by Mr. West, in the spring of 1900, gave total expenditures of feed-water ranging from 100 to 600 pounds per hour, delivering from zero to 10 brake horse power, from zero to 5 kilowatts and zero to 6½ electrical horse power; while the "water-rates" ranged from 64 to 56 per engine horse power and from 105 to 65 per kilowatt between 15 and 50 amperes at 110 volts, the latter variations following closely the hyperbolic law.

The form of the Laval turbine is seen in the accompanying sketches, of which the first exhibits the form of the 10 horse power, 6.6 kilowatts, set, the tests of which in Sibley College are elsewhere reported.

The details of the construction of this simple turbine are seen in the following illustration, in which the section of the nozzle and of the rim of the disk of the turbine permits an excellent and very clear representation of the process of energy conversion here carried on in the impact turbine. Three jets are shown, but the number may be made greater or less, as may be found in any individual design best. The wheel evidently belongs to the class of "partial turbines," as the hydraulic motors of this type have been called. The succeeding figures show

* Paper read at the New York meeting (December, 1900) of the American Society of Mechanical Engineers.

the form of the gears, the turbine disk, and the nozzle separately. One important and peculiar feature of this turbine is the adoption, by its inventor, of a

SIMPLE IMPACT STEAM TURBINE.—SIBLEY COLLEGE, C. U.

C.—4 NOZZLES.

Speed. Revolutions per Minute.	Amperes.	Volts.	Dynamo. Watts Output.	Losses of Dynamo.		Engine. Watts Output.
				Hysteresis and Friction.	Resistance.	
2,352	19.3	110	2,127	1,410	300	3,837
2,260	38.7	110	4,253	1,350	350	5,953
2,238	58	110	6,380	1,325	431	8,136
2,218	58	110	6,380	1,300	431	8,111

Horse-power.		Output in B. T. U. per Hour.		Pounds of Condensed Steam.			
Electrical.	Engine.	Dynamo.	Engine.	Per Hour.	Per H.-P., Engine.	Per H.-P., Electric.	Per Kilowatts.
		A	B				
2.85	5.14	7,250	13,050	308	60	108	144.5
5.72	8.02	14,500	20,300	428	53.4	75	101
8.55	10.9	21,750	27,700	567	52	66.4	88.8
8.55	10.86	21,750	27,620	618	57	72.2	97

British Thermal Units.				Efficiency.	
Per Hour.	Per H.-P., Engine.	Per H.-P., Electrical.	Per Kilowatts.	Engine. B/C.	Eng. and Dyn. A/C.
				Per cent.	Per cent.
360,100	70,100	126,300	169,200	3.63	2.01
497,600	62,100	87,000	116,700	4.08	2.92
661,200	60,700	77,400	103,600	4.2	3.3
728,600	67,000	85,300	114,000	3.8	2.99

slender, flexible shaft which can spring sufficiently to permit the disk to whirl about its center of gravity, a point which never precisely coincides with its center of figure; this expedient allows of complete avoidance, in a well-made turbine, of the jar otherwise produced.

Trials of a similar Laval turbine reported by Prof. Goss to the American Society of Mechanical Engineers * give figures as in the following table:

RESULTS OF TESTS, LAVAL TURBINE.

Nozzles.	Number of Test.	Revolutions per Minute of Belt Wheel.	Brake Horse-power.	Steam Pressures by Gauge. In Boiler.	Steam Pressures by Gauge. In Engine below Governor Valve.	Total Pounds of Steam per Hr.	Pounds of St'm per Brake Horse-power per Hour.
All four nozzles in action, three having a diameter in throat of 0.138 inch and one a diameter in throat of 0.157 inch..	1	2,138	**0.00**	130	17.1	120.8	.. ...
	2	2,545	**1.63**	130	42.2	210.3	**128.6**
	3	2,038	**2.36**	130	48.5	230.8	**99.8**
	4	2,118	**2.97**	130	55.6	254.6	**85.7**
	5	1,917	**3.46**	130	61.9	275.5	**79.6**
	6	2,072	**4.38**	130	70.8	313.0	**71.5**
	7	2,128	**5.10**	130	76.9	328.5	**64.4**
	8	2,576	**7.52**	130	99.6	403 0	**53.6**
	9	2,453	**8.24**	130	104.4	422.8	**51.3**
	10	2,411	**10.33**	130	126.3	491.8	**47.8**
Three nozzles in action, two having a diameter in throat of 0.138 inch and one a diameter in throat of 0.157 inch..	11	2,584	**0.00**	130	81.3	121.4	......
	12	2,112	**3.95**	130	83.6	267.8	**67.8**
	13	2,125	**4.77**	130	93.4	286.0	**60.0**
	14	2,490	**6.50**	130	111.7	346.3	**53.3**
Two nozzles in action, each having a diameter in throat of 0.138 inch	15	2,546	**0.00**	130	42.2	99.3	.....
	16	2,049	**1.95**	130	83.5	162 6	**83.4**
	17	1,909	**3.43**	130	121.1	222.9	**65.0**
	18	2,412	**3.87**	130	127.0	229.6	**59.3**

The lowest figure here obtained is 47.8 pounds of feed-water per horse power per hour delivered upon the

* Trans. A. S. M. E., December, 1895, vol. xvii., p. 81.

brake, which corresponds to about 43 pounds per independent horse power with the reciprocating engine.

The results of trial of a 50 horse power Laval turbine are reported by Prof. Cederblom, of the Polytechnicum at Stockholm, his assistant, Mr. Anderson, and the inspector of the Board of Trade of Stockholm, Mr. Uhr, May, 1893, as follows:

The test continued for 8 hours, from 9:45 A. M. to 5:45 P. M., during which time 617.5 kilogrammes South Yorkshire coal and 4,651 kilogrammes feed-water of an average temperature of 15.4 degrees Celsius were consumed. The effect was determined by brakes; the number of revolutions was 1,645 per minute. The steam was obtained from a fire-box tubular boiler, at a pressure of 8.6 kilogrammes per square centimeter above the atmosphere. The motor was close to the boiler. In the steam piping, between the boiler and the motor, a water-separator was inserted.

The steam pressure was determined by a manometer, placed between the throttle-valve and the turbine. This pressure varied between 8.6 and 7.6 kilogrammes per square centimeter.

The pressure in the exhaust-pipe was constant during the whole test = 0.12 kilogramme per square centimeter absolute pressure or 67 centimeter vacuum.

The exhaust steam was condensed by an ejector condenser, fed by a centrifugal pump, driven by another motor which obtained steam from a separate steam boiler. The circulation water was warmed up by the steam from + 7 degrees to + 16 degrees Celsius

During the trial, the turbine developed 63.7 effective horse power.

This gives per hour and brake horse power:

$$\text{The consumption of steam, } \frac{4561}{8 \times 63{\cdot}7} = 8{\cdot}95\ kg.$$

$$\text{The consumption of coal, } \frac{617{\cdot}5}{8 \times 63\ 7} = 1\ 21\ kg.$$

These figures, corresponding to 19.7 pounds of steam and 2.66 pounds of coal per horse power per hour, at the brake, may be accepted as again exhibiting the capacity of the turbine, properly operated, and its promise as a rival of the common forms of even good engines where, as here, employing 108 to 122 pounds steam pressure and with a vacuum of 26 inches. The gain progresses, in the steam turbine, with increasing loads up to the limit of power of the machine; in which respect it departs markedly from the case of the common forms of engine. In the steam turbine, there is no overload except as fixed by its maximum

power, and its rated best load and its maximum capacity are identical.

Some ten years ago a steam turbine was built in the shops of Sibley College and reported upon by Messrs. J. C. Brown and W. B. Lachicotte. It was made a "compound" or series turbine, of the Dow form (Figs. 22, 23), with steam passages through stationary guides and systems of vanes in alternation, the general direction of flow being radially outward,

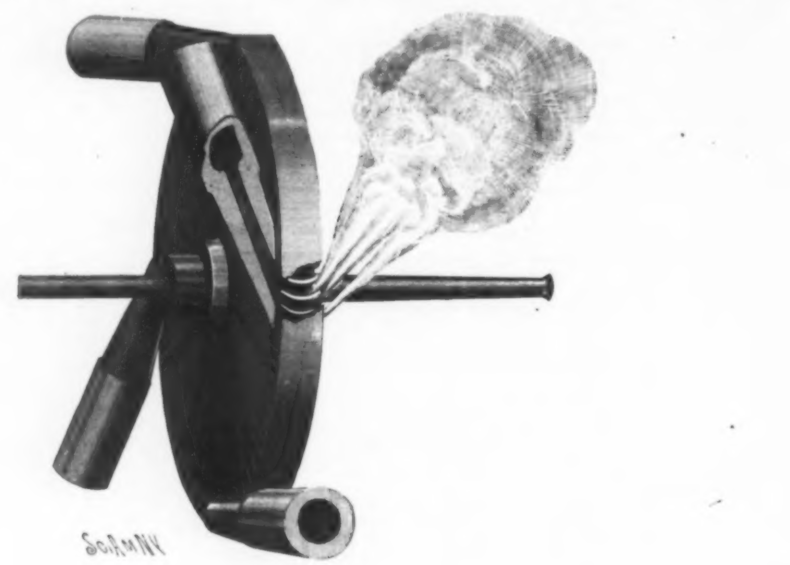


FIG. 18.

thus taking advantage of the enlarging areas of section to meet the requirements of the expanding steam. The annular spaces between guides and turbine passages form reservoirs and feeders, and equalize pressures throughout the annulus. Compounding, with the steam turbine, is thus a vastly more simple and satisfactory operation than with the reciprocating engine, and this is particularly true of the outward-flow series type. Its purpose obviously, however, is altogether different in the two machines. The turbines are not subject to "cylinder condensation," and

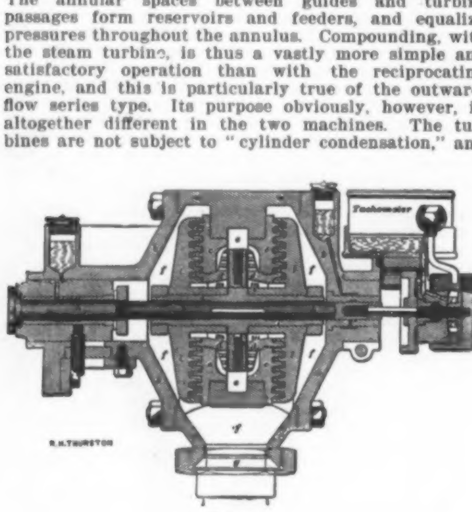


FIG. 22.

are compounded only to secure at once, satisfactorily, complete expansion and reduced speed of rotation; their speed is, at best, too high for general purposes in engineering.

In this machine, the frame and the end covers were of cast iron and the disks of aluminium bronze, to the conductivity of which no objection arises in this type of motor. The number of passages in the wheel was 10 at the axis, increasing to 13 in the next set of vanes, 16 in the third, and thus up to 26 at the periphery of the machines, while the guide passages

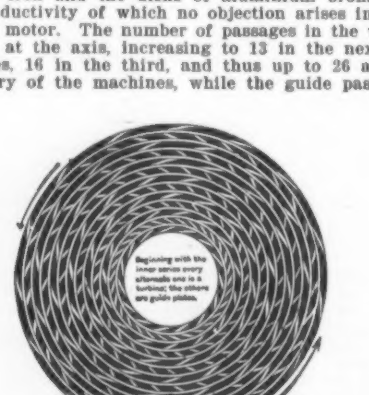


FIG. 23.

ranged in number from 26 to 56. The guide passages made a constant angle of 95 degrees with the turbine passages, at entrance, and the latter, at the exterior of the wheel, were set as nearly tangent as the construction permitted. Accuracy of construction to within 0.001 inch was required. The speed of revolution was made 21,000 per minute and, at this speed, the effort of an unbalanced mass of one pound weight would be, at the circumference of the turbine, 37,500 pounds. The stress on the disks at this speed was computed as 14,000 per square inch of metal. The tenacity of the latter was about 70,000, as determined by test. The flywheel was 5.57 inches in diameter and weighed 132 pounds. Its energy is 477,160 foot-pounds at 10,000 revolutions a minute. The turbine would spring it up to that speed in one minute; thus exerting 14.5 horse power as a mean or 29 horse power as a maximum and its rated power. Turbines of this construction were reported to demand from 20 to 50 pounds of steam per horse power per hour. This machine had a diameter of disks of 6½ inches and a depth of passage of about a half inch.

Messrs. Johnson and Mott made a magnetic brake with which to test this turbine, spinning a disk of steel between a pair of powerful magnets and relying on the work of production of Foucault currents to provide resistance. The brake was coupled directly to the engine shaft. It was found that this resistance varied as the square root of the speed and the curves on the speed-load diagram were parabolas. The power absorbed varied as the square root of the current and as the square root of the number of ampere turns active in producing the magnetic field.

In this brake, the use of water to hold down the temperature of the disk was, of course, necessary, and the resistance of the water to acceleration conspired with that of the dynamometer proper to produce total resistance. In later experiments at high speeds of rotation, a simple disk running in still water, and water renewed only as required for cooling, was employed very successfully.

Prof. Kennedy, testing a Parsons turbine, with steam superheated to various degrees, found the consump-

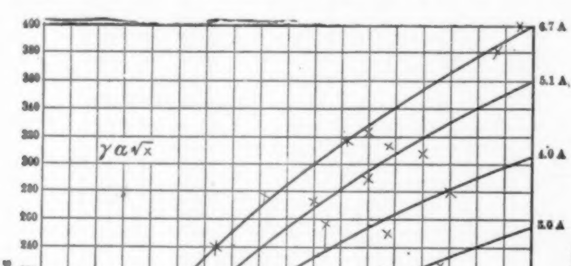


FIG 24. RESISTANCE OF MAGNETIC BRAKE.

tion of steam per electrical horse power per hour, with 97 pounds steam pressure, 14 inches vacuum, developing from 37.5 electrical horse power to 164.9, to vary from a maximum, 32.9 pounds at the smallest power and with 20 degrees F. superheat, to 23.3 at 92 electrical horse power with 37 degrees F., to 20.8 at 148.5 electrical horse power and 67 degrees superheat, and to 20.3 pounds at 165 electrical horse power with 55 degrees superheat; but just how the gain is to be apportioned between that due to increasing delivery and to increasing superheat is uncertain.

Rateau reports the results of about forty experiments with a turbine having a disk thirty centimeters in diameter (12 inches, nearly), selected, as he states, from thousands, in which the total efficiency, the ideal taken as unity, ranges, for engine and dynamo attached, from three to four tenths, averaging about 0.375, with initial steam pressures of about eight atmospheres, back-pressures one atmosphere, revolutions 6,000 and consumption per kilowatt hour of 25.3. The highest figures for efficiency are 0.408, with ten atmospheres steam pressure, one-third atmosphere back-pressure, 18,000 revolutions, and 16.5 kilogrammes (35 pounds) per kilowatt hour. The voltage was usually about 100, the amperage rose, in the case last cited, to 342 with 118.5 volts, 40.6 kilowatts. The best results were secured with two nozzles. By total efficiency is here understood the ratio of electric energy developed by the dynamo to the total energy computed as available in the steam supplied. Plotting the speeds and efficiencies of this turbine, it was easy to ascertain the influence of the latter upon the former, and it proved that a higher speed, 21,500 revolutions, would have been better than the speed actually adopted with this individual machine and would have given a total efficiency of 0.45, more than ten per cent of its own value higher than the best figure attained during the series of trials reported. This would have given a speed of periphery of about 325 meters per second, 1,066 feet per second, 63,960 feet per minute, 300 miles an hour nearly.

The efficiency of the turbine, apart from its driven mechanism, the dynamo, in this case, approximates in the assumed case of 50 per cent that of the ideal, reckoned from efficiency unity for heat transformation. This is equivalent to saying that the steam turbine, in this case, demands twice as much steam as its ideal prototype, the perfecting steam-engine working in the Rankine-Clausius cycle. This, in turn, means wastes of one-half of the heat supplied and probably in some such proportion as this: friction of journals and of fluid, 10 per cent each, 20 per cent, conduction and radiation 10 per cent, leakage 20.

The Curtis Steam Turbine, a more recent invention, is to be classed with the axial turbines and is a compound wheel. A pair of wheels turn on a single shaft, the one taking steam from a nozzle suitably adjusted and conducting the steam from the steam-pipe and boiler to the turbine; the other taking the expanded steam rejected from the first turbine and still further reducing its pressure while it expands to the lower limit of tension and higher limit of volume, at this limit discharging it into either the atmosphere or a condenser. The intermediate guide-curves are mounted upon a fixed disk, set between the two revolving turbine-disks. By thus compounding, this turbine, like other compound machines, is adapted to a comparatively low velocity of rotation. The novel feature of the machine, as disclosed by reference to the patent-drawings, is seen to be a peculiar and ingenious form of nozzle which permits the adaptation of the steam-supply to the requirements of the load, by the automatic action of the governor, at a constant and maximum initial tension, thus avoiding throttling and permitting the maintenance of boiler-pressure, approximately, and the complete utilization of the thermodynamic advantages of full boiler-pressure and most complete expansion. The delivery of steam may also be made to take effect at several vanes in a group and some reduction may be thus effected in the leakage waste.

Reported tests of this turbine give a performance, at a steam-pressure of 130 pounds by gage, and with a vacuum of 28 inches, of 24 to 27 pounds of steam per horse power hour, measured by the brake, and at 2,800 revolutions per minute, with powers ranging from about 125 down to 40, non-condensing figures are given as 35 to 45, between 180 and 60 horse power, as compared with a probable 20 to 45 pounds of feed-water under similar ranges of condition for the reciprocating engine. Its weight is about one-fifth that of the latter at similar powers, and it has about one-tenth the volume.

The Effect of the Presence of Water in the Steam Driving a Steam Turbine thermodynamically is practically *nil*. This is shown both by a study of the form of the expression for thermodynamic efficiency of the type-cycle, in which it is evident that no ordinary amount of moisture, at least, could affect its value, by the examination of the expansion-curve, in the cycle, which is the only part of the cycle affected by the introduction of water with the steam, and also, and more convincingly, by direct experiment.*

That the removal of moisture from the steam and the provision of superheated steam effects an important gain in the steam-turbine has been known from the earliest work of Prof. Ewing made with this com-

* Prof. Jacobus has shown this fact by direct experiment, and frequent experiments, direct and indirect, on other forms of heat-motor, on record in the transactions of the A. S. M. E. and elsewhere, prove that, while the slightest amount of superheat produces a relatively important gain, the quality of really wet steam may greatly vary without perceptible variation of efficiency, whatever the type of engine.—Trans A. S. M. E., 1897, vol. xviii., p. 608.

parison n view. What is the method of gain, however, may not be so easy to see, when it is understood that it cannot be a thermodynamic gain of any large amount. That a gain in capacity may be secured by superheating has probably not been realized by the average practitioner, even though familiar with the principles and practice involved in the production of the steam-turbine of high efficiency.

Comparing the reported efficiencies of the steam-turbine with the ideal efficiency of the representative cycle, it is seen that there is a large discrepancy to be accounted for, as large as in the case of the ordinary engine;* while it is equally evident that it cannot be attributed, as in the piston-engine, mainly to internal condensation due to varying temperature of metal in contact with the working fluid. Thus, in the turbine operating with one hundred pounds boiler pressure and with a vacuum of 26 inches, corresponding practically to two pounds back-pressure, absolute, the demand for steam with complete expansion should be about 10 pounds of steam or feed-water per indicated horse power, and about 10,000 British thermal units per unit of work and time; while the best work of the real steam-turbine is about double this quantity for similar conditions, so far as obtainable. One-half the power-equivalent of the heat supplied in the steam is thus lost. This loss cannot have occurred through the action of "cylinder-condensation"—which might account for it in a wasteful steam-engine of the common type—but must be traced to *either* enormous friction or equally remarkable waste by leakage or by conduction and radiation. The latter, however, must be less than in the piston-engine; for the new motor is much smaller and has smaller radiating surfaces for similar heat expenditure and power-development. Leakage might readily account for such losses and more; but a well-made steam-turbine need not be subject to this waste in very extraordinary degree. The one remaining possible source of serious loss of power is friction. The friction or rubbing is comparatively small and can be readily ascertained with a fair degree of accuracy, as it is comparable with that of the cotton-spindle. The waste is not at that point; it apparently can only be fluid friction and that may be very large at speeds of relative motion of surfaces between which water may be caught, such as exist in the steam-turbine. It is probably, therefore, fair to assume that we have found the main cause of the difference between the efficiencies of the ideal and of the corresponding real steam-turbine; fluid-friction, friction of water carried into, or produced by, condensation caused by exit of heat from the machine.

Two essential conditions in operating the steam-turbine are thus found to be required to insure the highest efficiency of the steam-turbine. These are obvious thermodynamic requisites, but their advantage in this case is not all, or even, in the case of one of them, certainly, mainly, due to thermodynamic gain. They are (1) the use of superheated steam, (2) the employment of a good condenser and a minimum back-pressure.

The reason of the importance of these conditions, and of their effectiveness in securing a good performance with any given machine, is the extreme susceptibility of this form of motor to friction-wastes of energy and loss of efficiency through seemingly minute resistances.

The influence of friction in producing wastes of energy in a fast-running machine are at once realized and appreciated when it is considered that the work thus wasted is the product of a resistance into a distance, and that, in the case of the steam-turbine, the velocity is enormously greater than that of the performance of work in any other motor. The factor of that lost work represented by the resistance, at any given value of the product $R \times V$, is reduced in proportion to this magnified speed.

A steam-turbine of ten inches diameter is operated regularly at 20,000 revolutions a minute; its velocity of periphery is thus about ten miles a minute, 600 miles, 500 knots, nearly, an hour. In the formula for horse power of vessels, calling V statute miles,

$$I.\ H.\ P. = S\ V^3/20{,}000,$$

for unity of area, $S = 1$, this gives the horse power to drive one square foot of area through water at 500 nautical miles an hour, as

$$I.\ H.\ P. = 500^3/20{,}000 = 6{,}250\ H.\ P.;$$

above 6,000 horse power to drive one square foot through water at the rate at which the periphery of the steam-turbine sometimes moves. One of our recent transatlantic steamers would demand 320,0..,000 horse power at this speed.

Assume a drop or a film of water to lie between the disk of the turbine and the casing, and to act in resistance as does water on the surface of a ship in motion, the film to have a superficial area of one one-hundredth of an inch; the resistance would be the above figure, 6,250, divided by 14,400, nearly one-half of a horse power for each drop. Assume a thread of water in the steam-turbine, between wheel periphery and casting, having the measure, 0.001 inch width and 31.416 inches length, 0.03 square inch area; its resistance under the conditions would be about one-half horse power.

Assume a drop of water, one-tenth of an inch in diameter, to drip from the casing upon the wheel and thus to take up energy otherwise transferred for useful work. The energy wasted would be the product of the weight into the half-square of the final velocity, $\frac{1}{2}\ m\ V^2 = \frac{1}{2}\ w\ V^2/g$; or, in feet, seconds, pounds, and foot-pounds, the loss per minute is

$$E = 120 \text{ foot-pounds, nearly,}$$

or practically one horse power per each 275 drops, at the periphery of the wheel. It is possibly the fact that drops could hardly fall upon the wheel in such manner and numbers as to produce so important an effect; since the drops are usually carried on with the stream of motor fluid and bring energy into the turbine, which may be surrendered to the motor rather than absorb energy from it; but that there is more or less of friction of the kind here discussed, and some action of the kind just referred to, undoubtedly occurs. What is sought here is simply to impress upon the mind the enormous influence of friction upon the steam-turbine in reduction of its efficiency. Even the shaft-bearings have a rate of waste of power, due their high velocity of rubbing surfaces, that would hardly be anticipated by one who had not looked into that matter.

Assume a shaft one inch in circumference at the journal, spinning at the rate of 20,000 revolutions per minute, and its friction to be one-fourth as great as if running in water; then the length of journals being total, two inches, the area of rubbing surface would be 0.014 square foot; its velocity is 1,666 feet per minute; its resistance, on the basis assumed above, would absorb nearly a fifth horse power. Precisely what is the friction of a lubricated journal at these speeds is not known; but its resistance would undoubtedly follow the law of increase with speed illustrated by all fluids; the deduction following that, with the steam-turbine, the necessity of insuring minimum friction of journals, as well as of disk rotation within the atmosphere of vapor, air, and rain, or mist, or both, which surround it, is vastly more imperative than in the case of ordinary machinery of comparatively low speeds of moving parts.

The cream separator and other "centrifugals" are admirable, as affording opportunity to employ the peculiar form of motor with which we have here to deal. They are speeded up to 5,000 or 10,000 revolutions per minute; and even the reaction steam-wheel of Hero may do very good work with them in competition with the small and wasteful steam engine of reciprocating type constituting their alternative. Standard speeds are 6,000 to 7,500 revolutions per minute, and a common performance gives about 3 horse power per 1,000 pounds of milk separated in ordinary creamery work.* Some, however, are far more efficient than others. The steam consumed in reported trials is given as 40 pounds per horse power hour, which is much below the consumption of the average steam engine of similar power—say, 3 to 5 horse power.

When it is considered that at a not unusual speed of periphery of the disk of the centrifugal 6,600 feet per minute, the impulse factor for 1 horse power is but 33,000/6,600 = 5 pounds, and that for the range 25,000 to 50,000 feet per minute, which may be taken as that of the working of the steam-turbine in commercial sizes, it is as low as from 1.3 to 0.66 pound at the radius of the wheel, it is easily realized that the slightest friction, whether of solids, of fluids, or "mediate," must sensibly affect efficiency. It is thus easily understood that even the friction of the air or the atmosphere of vapor surrounding its whirling disk, the touch of a drop of water or the presence of a film or a thread of water in the capillary space between the disk and the casing or between two adjacent disks, may seriously affect its economical operation, and that of any high-speed machinery driven by this prime mover.

Velocities of from 5 to 10 miles a minute, 300 to 600 an hour, are as difficult to appreciate and understand as to deal with in this construction. The work constitutes a new department of mechanical engineering. The flow of the steam into the passages of the steam-turbine at the pressures, now usu l, of 150 pounds per square inch, absolute, approximates 3,000 feet per second, 180,000 feet (nearly 35 miles) a minute, 2,100 miles an hour, and the minimum velocity of periphery of the simple turbine of the Branca type, for the ideal and perfect machine, should be one-half this figure, and for the Hero type, infinity. To meet this demand the engineer must employ metal capable of safely withstanding a stress of great magnitude, even for the Branca turbine; and he can never operate a perfect Hero engine at its speed of maximum efficiency, although, fortunately, the loss of efficiency down to attainable speeds is comparatively small.

Conclusions follow from what has preceded, which bear directly and in an important manner upon the principles of design of the steam-turbine and its operation as a source of power:

(1) The steam-turbine thermodynamically approximates in its real form more closely to the ideal than does any other type of heat-motor. Its cycle lacks only the introduction of the Carnot compression.

(2) It is entirely free from that waste which in the real steam engine of common type constitutes usually, if not invariably, the most important of its extra thermodynamic losses.

(3) It is peculiarly well fitted for use with those very high steam pressures as we now regard them, which must ultimately probably be resorted to by the engineer designing heat engines in his endeavor to further improve the efficiency of that class of motors.

(4) It is only limited in speed of rotation by the strength of its materials of construction.

(5) It is especially suitable for use with superheated steam, it having no rubbing parts on which lubrication may be difficult, in presence of superheated steam, and the limit to the superheat, so far as the motor is concerned, being only found at that point at which increased temperature of metal produces reduction of tenacity in objectionable amount. That limit, not as in earlier days of lubrication with animal oils, and still with other engines, is fixed with this machine at the boiler.

(6) As to its operation, it is obvious that friction is peculiarly active for evil in this motor, and that small diameters of journal, freedom from contact of part with part, except as absolutely required by the construction, and minimizing fluid friction by superheating steam, and by securing as complete removal of the atmosphere, air, or vapor from about the revolving wheel as practicable, must be carefully sought in order that the mechanical efficiency of the machine shall be made a maximum.

(7) The wastes of the steam-turbine are all extra thermodynamic; the loss due, the absence of adiabatic recompression excepted. They consist of (1) journal-friction, which is made a minimum by the use of a flooded bearing and a light unguent; (2) fluid friction between disk and leakage, steam, or suspended moisture in the jet, which may be made a minimum by superheating, and between the disk and its inclosing atmosphere of vapor, which may be minimized by the employment of a good condenser; (3) loss of heat and of steam by leakage, which may be reduced to a minimum by durable material, fine workmanship, and close fits; (4) waste by incomplete expansion, which may be reduced to a limit determined by the finance of the case, by the resultant increase of friction and of cost due the necessary enlargement of the turbine; and, finally (5), thermodynamic waste by failure to secure that complete adiabatic recompression of the fluid which is necessary to convert the Rankine-Clausius cycle into that of Carnot. The latter is a peculiarly difficult matter with the steam-turbine, since it probably necessarily involves the employment of a separate vapor-compression pump of special character, and an amount of added work and cost which may introduce losses more than compensating its gains.

* Trans. A. S. M. E., No. 832, 1899, vol. xxi., p. 185.

* "Test of Cream Separators," by H. H. Wing, Cornell University Bulletin, No. 66, May, 1895, p. 173.

CONTEMPORARY ELECTRICAL SCIENCE.*

DIFFUSION OF IONS IN AIR.—J. S. Townsend has continued his interesting researches on the rate of diffusion of ions in various circumstances. His latest investigations concern ions produced at various pressures by the action of a radio-active substance, and also determinations of the rate of diffusion of ions produced in air at atmospheric pressure by the action of ultra-violet light and point discharges. The principle of the method consisted in calculating the coefficient of diffusion from observations on the loss of conductivity of a gas as it passed along metal tubing. The experiments were so arranged that in all cases the loss of conductivity due to diffusion should be much greater than the loss due to other causes, so that it was not necessary to apply any corrections for losses arising from recombination or from the mutual repulsion of the ions. It appears that in every case the rate of diffusion of ions into a gas is inversely proportional to the pressure. The negative ions which are produced when ultra-violet light falls on a zinc plate diffuse into air at nearly the same rate as the negative ions produced by a radio-active substance. The values of the coefficients of diffusion for dry and moist air are 0.0435 and 0.0375 respectively. The rates of diffusion of ions produced by a point discharge have coefficients varying between 0.021 and 0.039, being highest for negative ions in moist air.—J. S. Townsend, Proc. Roy. Soc., October 26, 1900.

POSITIVE AND NEGATIVE HALL EFFECTS.—E. van Everdingen describes a novel effect obtained with a prism of bismuth cut by Perrot, of Geneva, from a block of the slowly-cooled metal. The effect is described as follows: A bar of bismuth cut at right angles to the principal crystallographic axis shows, in a magnetic field of about 5,000 C. G. S. units, when placed with the principal axis normal to the lines of force, a Hall effect of normal magnitude and normal (negative) sign; when placed with the principal axis parallel to the lines of force, it shows a small, positive Hall effect. Hence the same bar of bismuth which in one position shows a Hall effect similar to, say, that of nickel, on being turned through 90 degrees shows a Hall effect similar to tellurium and antimony. With regard to the effect this discovery will have upon the electron theory, the author thinks that the reversal of sign need not present a very formidable difficulty, particularly as the theory has already to reckon with reversals. The Hall effect is supposed to be proportional to the difference of migration velocities. Since v, the velocity of the negative ions, is more susceptible to change than u, the velocity of the positive ions, the cause of the reversal observed must be sought for in a large alteration of v, which reverses the sign of $u—v$.—E. van Everdingen, Proc. Akademie Amsterdam, October 24, 1900.

ENERGY OF BECQUEREL RADIATION.—To obtain some idea of the amount of energy involved in Becquerel rays, E. Rutherford and R. K. McKling have studied them in conjunction with Roentgen rays, and compared the thermal and electrical effects produced by the two kinds of radiation. The discharge producing the Roentgen rays had a frequency of 57 per second, and assuming that the duration of each impulse was 10^{-5} sec., the bolometer readings indicated a maximum energy of 19.5 calories per second from each square centimeter. This is 560 times the heating effect of the sun's rays per square centimeter at the earth's surface. The intensity of the Roentgen rays falling on a fluorescent screen is easily obtained by multiplying the luminous intensity of the screen by 23, that being the proportion in which the incident energy stands to the radiant energy of the screen. The amount of energy required for producing a single ion is about 1.9 by 10^{-10} ergs, which is considerably above that required for the electrolysis of water. As the ions produced by some Becquerel rays are probably the same as those produced by Roentgen rays, the energy of the former may be deduced from that of the latter. For uranium oxide the value obtained is 10^{-11} gramme-calories per second. In radium, whose energy is 100,000 times greater, the energy radiated per gramme of the substance is not less than 3,000 calories per annum.—E. Rutherford and R. K. McKling, Communication to Royal Society.

IONIZATION BY ULTRA-VIOLET LIGHT.—P. Lenard measures the velocity of ions produced by ultra-violet light by forcing a current of air through two flat nets in succession. The nets are made of linen threads rendered conducting by means of soap solution. The space between them is illuminated by ultra-violet light, taking care, however, that the limit of the illuminated space is 2 cm. away from the first net, which is positively charged. The second net is put to earth. When the blast is working without the rays, there is no loss of charge, but when the rays are turned on, with or without the blast, there is a loss of charge due to the ionization of the air. As the blast increases in strength the negative ions which seek to approach the positively-charged screen are blown back, and when the velocity of the air is 1.3 m. per second there is no more loss. That, therefore, is

* Compiled by E. E. Fournier d'Albe in The Electrician.

the velocity of the negative ions. With the E. M. F. used this gives 3.13 cm. per second for a potential gradient of 1 volt per centimeter. The corresponding value for the positive ions is 0.0015 cm. per second. The author obtains for s, the sum of the radii of the molecule and positive electron, the value 56 by 10^{-8} mm., or about 70 times the diameter of a molecule. This means that the positive electron consists of a large number of atoms, even if it only carries one elementary charge, e.—P. Lenard, Ann. Physik, No. 10, 1900.

DR. PUPIN'S IMPROVEMENTS IN LONG-DISTANCE TELEPHONY.

By HERBERT T. WADE.

SOON after the laying of the first Atlantic cable, nearly fifty years ago, Sir William Thomson prophesied that it would not be possible to exceed a certain rate of speed in the transmission of signals, on account of the so-called capacity of the cable. This prophecy has held good, for, notwithstanding multiplex and mechanical systems of telegraphy on land, the submarine cables are operated at an average speed of but twenty-five words a minute. The use of a submarine cable in telephony over a greater distance than twenty-seven miles in length (Dover-Calais) is not supposed to be practicable, and consequently telephonic communication is not available where a large body of water must be crossed. In telephone circuits where aerial wires are employed, there are also limitations, and yet long-distance telephony on such a scale as is desired, from New York to New Orleans, or San Francisco, for example, has not been attained, and is admitted by telephone engineers to be next to impossible.

After a series of experiments performed at the laboratory for electro-mechanics at Columbia University, Prof. M. I. Pupin has ascertained that with cables and air line conductors constructed according to a method thus far employed in the construction of long-distance electrical conductors, which involves a somewhat radical but nevertheless a very simple departure from the methods, the efficiency of transmission of electrical energy is greatly increased, and that a number of the difficulties just enumerated may be readily overcome. The method may be stated broadly to consist in employing what Prof. Pupin calls non-uniform conductors in place of ordinary uniform conductors. In the course of his experiments he has made use of such conductors for long-distance telephony, and the researches in his laboratory have been marked with great success.

Electrical energy when sent over a conductor of such length as is used in long-distance telegraphy or telephony is transmitted in the form of electrical waves. The transmission of the energy under such conditions can hardly be called direct, for it is first stored up in the medium surrounding the transmission line and from here it is then transferred to the receiving apparatus. If a periodic current is impressed on the circuit by the transmitting generator, we have periodic variations of current and potential along the transmission wire.

In the study of electrical waves it is found that the amplitude of the wave diminishes as the energy is propagated from the source. In short, a weakening of the current is caused which is styled attenuation, and for the constant of attenuation there is a mathematical expression in which the inductance, resistance and capacity of the conductor, and the frequency speed figure. The loss of energy is due to the imperfect conductivity of the wire, and it is regulated by the inductance and capacity in the circuit. The most important feature of this regulation is the following: If a conductor has a high inductance, a given quantity of energy will be transmitted with less loss than over a conductor with a smaller amount of inductance. This fact was known to Oliver Heaviside, the mathematical physicist of England, and while his theory demonstrated the superiority of a wave conductor of high inductance, it did not indicate a way in which such a conductor could be constructed. The mere introduction into the circuit of a coil or coils has been tried without success, as there was no underlying mathematical theory to govern the experiments.

Prof. Pupin, however, has developed such a theory, which serves to explain the problem, and its main features are well shown in a mechanical illustration in which the same elements are present as are found in the question of the transmission of electrical waves. To one prong of a tuning fork rigidly fixed at C is fastened a cord whose other end is attached to some firm object as D, shown in the illustration (Fig. 1). Let the fork be set into vibration and a wave motion results, which, if the resistances due to friction are negligible, will take the form of stationary waves, as shown in Fig. 2. But, assuming that the frictional resistances are not sufficiently small to be neglected, then the direct and reflected waves will not be equal, and instead of stationary waves there will be waves where the amplitude of the particles at the greatest distance from the tuning fork will be less than that nearer the source of motion, as shown in Fig. 3, the energy being dissipated by the frictional resistances in its progress along the cord. This weakening or attenuation, however, will be diminished if a string of greater density is employed, since a larger mass requires a smaller velocity in order to store up a given amount of kinetic energy, and a smaller velocity occasions a smaller frictional loss. Now let a weight, such as a ball of wax, be attached to the vibrating cord at its middle point so as to increase its mass. This weight will serve to occasion reflections, and there will be far less energy transmitted to the extremity of the string than before. Then, if the mass of wax be subdivided, and put at regular intervals, as shown in the diagram (Fig. 4), the efficiency will be increased. The further we proceed in this subdivision the higher will be the efficiency of transmission, but a point will be soon reached beyond which it is not possible to secure an appreciable improvement by further subdivision.

This point is where the cord thus loaded vibrates very nearly like a uniform cord of the same mass, tension and frictional resistance, as we may see by reference to Fig. 5. Therefore, to secure an increase in the efficiency of transmission over a cord thus loaded, we must properly subdivide the load and the distances, or otherwise the effects of reflection will destroy the benefits derived from the increased mass. In the experiments with the cord it was found impossible to load the cord in such a way as to make it equivalent to a uniform cord for all wave lengths, but φ is the angular distance between the inductance points of inductance sources and the angular distance to 2π corresponds with the wave length. Here the value φ is inversely proportional to the wave length, so that for a given distance between the reactance points the degree of equivalence diminishes as the wave length diminishes. If the wave conducted be of complex nature, such as is met with in telephony

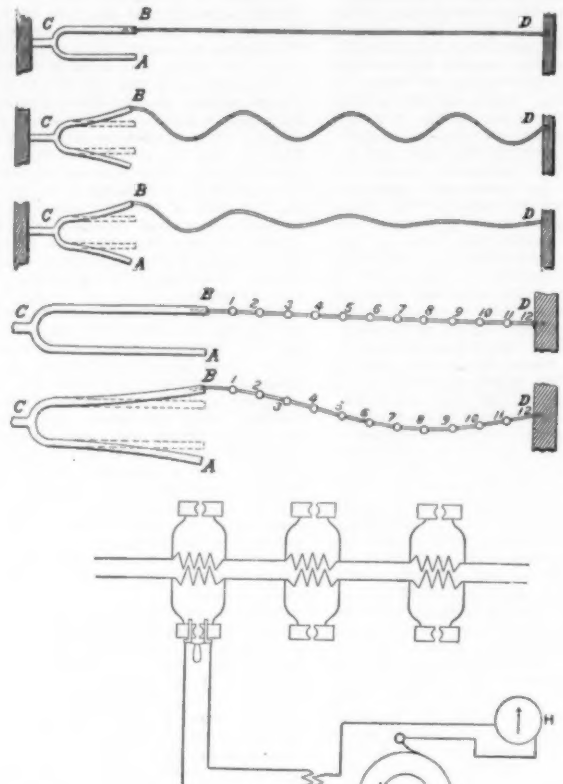


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

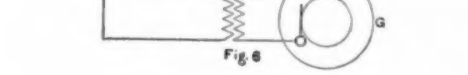


Fig. 6

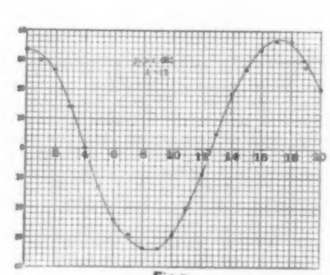


Fig. 7

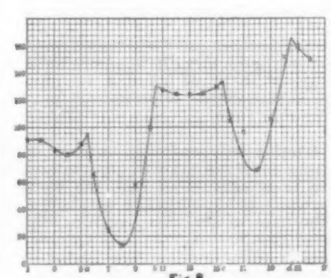
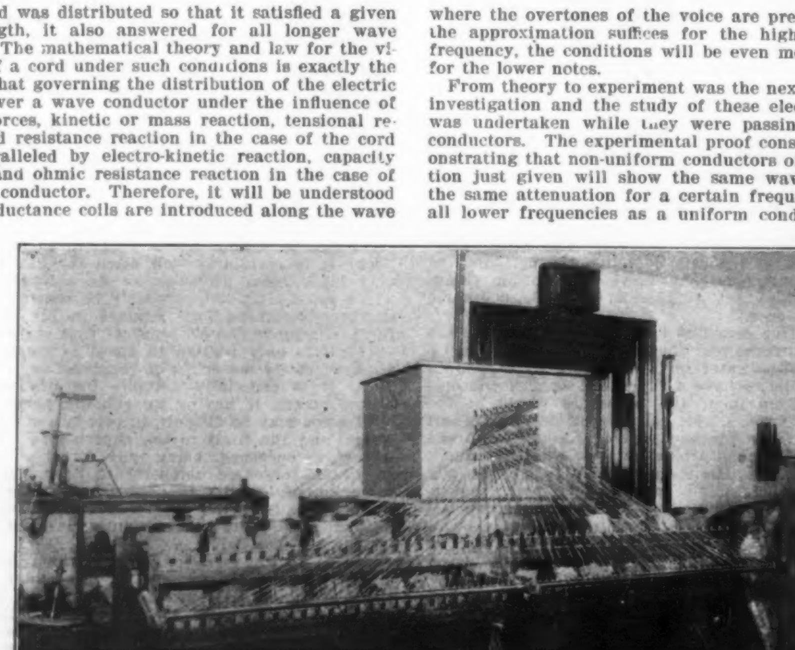


Fig. 8

PUPIN'S INVESTIGATION OF CABLE TELEPHONY.

if the load was distributed so that it satisfied a given wave length, it also answered for all longer wave lengths. The mathematical theory and law for the vibration of a cord under such conditions is exactly the same as that governing the distribution of the electric current over a wave conductor under the influence of similar forces, kinetic or mass reaction, tensional reaction and resistance reaction in the case of the cord being paralleled by electro-kinetic reaction, capacity reaction and ohmic resistance reaction in the case of the wave conductor. Therefore, it will be understood that if inductance coils are introduced along the wave where the overtones of the voice are present, then, if the approximation suffices for the highest essential frequency, the conditions will be even more favorable for the lower notes.

From theory to experiment was the next step in this investigation and the study of these electrical waves was undertaken while they were passing over wave conductors. The experimental proof consisted in demonstrating that non-uniform conductors of the description just given will show the same wave-length and the same attenuation for a certain frequency and for all lower frequencies as a uniform conductor of the



Arrangement of 250 miles of artificial line, with inductance coils at one-mile intervals, and telephonic instruments at either end.

FIG. 9.—EXPERIMENTAL CABLE WITH INDUCTANCE COILS.

conductor at periodically recurring intervals, the efficiency of the transmission of electrical energy is increased. Prof. Pupin's conclusion is that a non-uniform conductor is as nearly equivalent to its correspondingly uniform conductor as $\sin\frac{\varphi}{2}$ is to $\frac{\varphi}{2}$ where same inductance, resistance and capacity. The wave-length is of course conditioned by the frequency, and in the construction of the apparatus the periods used in long distance telephony were selected. The conductor selected was the counterpart of a cable 250 miles in length, having the equivalent resistance and

capacity. To construct such a cable was a task of much labor and three cables were made and experimented with, before the final form was reached which approaches very nearly the conditions existing in a submarine cable. This was formed of thin strips of tinfoil laid on sheets of paraffined paper and carefully connected, their length being sufficient to afford considerable resistance, while the capacity was regulated by the thickness of the insulating material. The strips were then connected in sections, each being equivalent to one mile of cable with a resistance of 9 ohms and a capacity of .074 microfarad, and were arranged in groups of fifty, one such group being contained in the heavy case shown in the center of the illustration, Fig. 9. Having a cable where there is resistance and capacity, it is possible to demonstrate experimentally the vigorous attenuation of the current and to study the propagation of the electrical waves. This attenuation, as has been said, is remedied by the insertion of inductance coils into the circuit, and the illustration and diagram show the method of adding such coils. The wires from the various sections of the cable are connected with brass plates placed on a long wooden strip and by means of plugs and binding posts the circuit can be regulated. At the gap between any two successive sections of the cable a coil or coils containing inductance can be added, and by merely inserting a plug can be cut out of the circuit. Using a small alternator, and circuits with suitable inductance and capacity, to impress a simple harmonic electromotive force the waves were investigated. The alternator was so constructed as to give currents of different frequencies and thus produce the circuit waves of different length. Then with a slide contact, *G*, and galvanometer, *H*, arranged as shown in Fig. 6, it was possible to ascertain the condition of the current at any point along the line. In this way observations were made and curves plotted showing the maximum and minimum amount of current and the length of the wave passing along the conductor. Such a curve is shown in Fig. 7, the numbers along the horizontal line in the middle representing the distance from the middle point of the cable, and the dots the current at various distances from this point.

Connecting these points we have a close approximation to an attenuated sine curve as required by the mathematical theory. In this case the wave length is 17 miles and the frequency 625 periods per second. Contrast this with the following illustration where the inductance is not properly placed in the circuit, and the result shows a remarkable attenuation and reflection of the waves. Leaving the exact mathematical considerations out of the question it may be stated if the induction coils are placed at intervals about one-sixteenth of the wave length the non-uniform conductor will be like a uniform conductor to within two-thirds of one per cent. If this is done the attenuation is made very small, comparatively speaking, and the electrical energy is transmitted with but slight dissipation. A numerical example will illustrate this more clearly. If the cable is employed with the inductance coils placed properly, then two and one-half per cent. of the current generated at the transmitting end reaches the receiving end of the cable. But if the coils are cut out and the cable used in the ordinary way, then only one two hundred and fifty thousandth part of the current sent in at the transmitting end reaches the receiving end. In other words, the insertion of the coils enables the cable to transmit 6,000 times as much current.

The first application of the results of this investigation has been to long-distance cable telephony. The cable being employed as before with the inductance coils at intervals of one mile, and at either end of the line two sets of ordinary telephonic instruments. Over this line of 250 miles of cable one can carry on a conversation distinctly, the fact seeming the more remarkable when it is realized that about 40 miles is the present limit for cable telephony and that the longest cables in the New York subways are 15 miles in length. These experiments from a purely scientific point of view demonstrate the feasibility of trans-Atlantic telephony.

It is, however, in regard to its applicability to telegraphy, that its advantages for marine work must be especially considered, where, as soon as the speed is increased the attenuation of the waves occurs and a limit is very early set upon the rate of operation. With the attenuation taken care of by inductance coils added at specified distances along the cable, the current would be transmitted with small loss to its destination and not only would the ordinary speed of operation be increased, but by the use of methods similar to those employed on land for rapid telegraphy the efficiency would be made many times greater. The inductance coils could be added to the conductor at certain distances and placed within the sheathing at small expense in comparison with the cost of the cable, and being made about one inch in diameter and six inches in length would create no particular difficulty either in the manufacture or in the laying of the cable.

The earliest application of this method will doubtless be to aerial conductors to increase the present limits of long-distance telephony now placed at St. Louis from New York. The inductance coils at slight cost can be attached to the cross arms of the poles and instead of the heavy copper wires now required, a smaller and less expensive conductor may be used. According to the theory and its experimental verification, there seems to be nothing to prevent a very wide increase in the limiting distance of modern telephony through the use of this method of constructing conductors, and trials in the field under actual conditions of service are anticipated with interest by telephone engineers. It is worthy of notice in connection with this discovery that its entire development has been carried on along strictly scientific lines by Prof. Pupin, to him being due the conception of the mathematical theory involved, its experimental verification, and, lastly, its application to an important technical problem.

BIDS have been asked from the United States to supply 20,000 rifles and 10,000,000 cartridges for Siam.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

The American Reputation in Trade.—In a previous report I expressed the opinion, based upon careful observation, that, "generally speaking, it is considered in Scottish communities that to say an article is American is to commend it," says Consul Rufus Fleming of Edinburgh. Further observation confirms this opinion. It is worth noting, as an illustration, that a recent issue of a British trade journal contained a paragraph to the effect that a Scotchman who had invented a mechanical device complained to a friend that he could not dispose of it, although it was an excellent thing; whereupon the other ingenious Scotchman advised him to advertise it as "the latest American invention," which he did, effecting a sale in a short time and at a good profit. I do not vouch for the story, but can vouch for something quite as much to the point, as follows:

In the Edinburgh directory for 1900 appear the company name and business designation, "Smith & Wellstood, Limited, American stove manufacturers, general iron founders," etc. They have offices and warehouses in this city and extensive works at Bonnybridge, Stirlingshire. The foundry is called the "Columbian Stove Works," and the stoves principally advertised in Edinburgh and elsewhere by Smith & Wellstood, Limited, as "American heating stoves" and "American cooking stoves." I have seen some of the stoves, both heating and cooking, and can testify that they are faithful copies of American designs. Not long ago, I sought for information from this company as to the styles and prices of their American patterns. The secretary replied courteously, by letter, that they must refuse my request, inasmuch as they "could not expect to do any business in the United States, owing to the tariff"; and he calmly added, not intending to be droll, that "it is as much as we can do to give attention to those markets where there is a fair field for our enterprise." To what extent the company has succeeded in its enterprise of selling "American" stoves of their own manufacture in the British and other markets, I have been unable to ascertain.

Another bit of evidence of the high reputation of the American name attached to manufactures came to my notice last week. Among the placards in the windows of the leading stationery store in this city is one which reads, "Real American playing cards," the word "real" being underlined. Any comment upon this placard would be superfluous.

Electrical Progress in Brussels. — The company which was organized in this district in 1898 to establish electric traction on navigable ways in Belgium closed its books for the first time on June 30, 1900, with a balance of 26,291 francs ($5,074). Nearly all the time since its organization has been devoted to erecting buildings and putting in machinery. Electric traction was first put into operation by the company between Virginal and Ruysbroeck, a distance of 22 kilometers (13.669 miles), and worked satisfactorily by means of thirty tractors and four electric tugs.

Eleven communes have already contracted with the company for public lighting for a period of thirty years, and other communes are negotiating for the same purpose. The company has recently submitted to the government proposals for lighting eleven railway stations between Brussels and Charleroi. The managers believe that before the ending of the third fiscal year, their contracts will embrace ten thousand lamps, which, estimated at 15 francs ($2.89) per lamp, will represent an annual revenue of 150,000 francs ($28,950).

Negotiations are now going on for supplying 242 horse power from ten to twenty hours per day. From this branch of the enterprise, the company calculates upon an annual income of at least 125,000 francs ($24,-125).

It is equipped to supply electricity for towing by day and night, for small and medium industries, and eventually for vicinal rail and tramway lines and night public lighting.—George W. Roosevelt, Consul at Brussels.

Glass in Egypt.—All kinds of glassware are at present much in demand in Egypt. In 1898, the imports of glassware (window glass not included) amounted to 1,500,000 francs ($289,500). Lamp glass in particular is wanted, and is principally imported from Austria and Germany. The increased use of gas has caused an augmentation of the sales of all kinds of articles for gas lamps. France, Austria and Germany also furnish large quantities of glassware for electric lamps. Goods out of pressed glass—as, for instance, salt and pepper stands, beer mugs, sugar basins and all kinds of table glassware of medium quality and prices, spirit and beer bottles and similar articles—are purchased in considerable quantities.

In 1898, the imports of glassware from Austria amounted to 570,000 francs ($110,010), and those from France to 260,000 francs ($50,180); after these come Germany, Belgium, Great Britain and Italy.

As regards china, Germany, Austria and Italy have increased their sales, while France seems to have been doing less business. England and Belgium have also considerably diminished their exports in this line. The French trade included the better-class articles, mostly from Limoges. Italy exports ordinary faïence goods, which are largely in demand on account of low prices.

Would it not be well for our glass manufacturers to cast an eye on Egypt as a likely market for their wares?—Oliver J. D. Hughes, Consul at Coburg.

Hints to Exporters of Paper.—According to a French report, Austria is crushing French competition in Egypt in the sale of cigarette paper, both on account of quality and price. In writing and printing paper also, Austria commands the Egyptian market, Italy and Great Britain alone competing to some extent.

From Durban, Natal, comes a Belgian report, according to which cardboard is an import article of some importance. The demand is only for first quality cardboard that will bend easily without breaking. Special care must be devoted to the packing of cardboard. It must be packed between wooden boards, wider and longer than the cardboard itself, in order to protect the edges. Belgian cardboard frequently arrives greatly damaged. Imported cardboard is chiefly used by bookbinders.

Waterproof cardboard is also exported to Natal, only of the following dimensions, however: 36 by 18 inches and from 4 to 5 millimeters (0.1576 to 0.197 inch) thick.

The demand for printing paper seems to be on the increase, but only in the better, well-glazed grades. Scotch and German makes are given the preference.—Walter Schumann, Consul at Mayence.

Business Depression in Germany.—A late number of the Brunswick Landeszeitung says that there is a decrease of 37.4 per cent. in building enterprises in Germany, as compared with the summer of 1899; of 58 per cent. in railroad projects; of 63.43 per cent. in construction of electrical and street railroads; of 32.33 per cent. in projected electrical plants for lighting, etc.

The number of projected gas works is almost a third less, but, in view of size and percentage of production, there is little difference. In other spheres of activity, such as mining and smelting, work in stone and earth (fertilizing salts, etc.), metal manufacture, production of chemicals and textiles, breweries and water works, the statistics show a difference of 27.2 per cent.

There have been quite a number of failures in all branches of business during the last seven months, and in my own consular district two of the oldest and best established glove manufacturers have become bankrupt. This depression is a natural reaction after so much prosperity. Germany was never so flourishing as during the year 1899. New business enterprises of all kinds were projected, and old enterprises increased their plants; future profits were discounted; new issues of securities were made to cover expected profits. The depression in the iron and steel trade in April last called the attention of the public to the actual condition of affairs, and this led to the general taking of stock. A judicious restriction of the spirit of enterprise followed, which averted an otherwise inevitable panic.—Talbot J. Albert, Consul at Brunswick.

Tariff Protection for the German Boot and Shoe Industry.—Under date of November 20, 1900, Vice-Consul-General Hanauer, of Frankfort, states that the economic committee of the German shoe and boot manufacturers, who lately met in convention at Berlin, resolved to petition the national legislature to raise the tariff on imported shoes, so that leather shoes weighing over 1,500 grams (3.3 pounds) henceforth should pay an import duty of 70 pfennigs (17 cents) per pair; those of 500 to 1,500 grams (1.1 to 3.3 pounds), 1.50 marks (36 cents); and all below 500 grams weight, 2 marks (48 cents). The association claims that this tariff is necessary to protect their important industry, which at present turns out a yearly product valued at 250,000,000 marks ($59,500,000) and pays 40,000,000 marks ($9,520,000) annual wages to 50,000 people employed in over 1,100 manufactories. This measure is aimed against the influx of American shoes.

Thread and Cloth Mill Concession in Nicaragua.—Consul Sorsby, writing from San Juan del Norte, under date of November 11, 1900, informs the Department that on the 22d of September last the government of Nicaragua granted Pedro Mas, a native of Spain, a concession to establish a factory for the manufacture of cotton threads and cloths, such as prints, percales, indianas, etc.

This concession, continues Mr. Sorsby, is made an exclusive privilege for a period of five years. It may be transferred (but not to another government), and shall at all times be subject to the laws of Nicaragua. Questions arising shall be settled by arbitration, and in no case shall be foundation for a diplomatic claim. The right to form and legalize foreign corporate associations is permitted, such associations to have a representative with full power domiciled in Nicaragua.

Peruvian Steamship Company.—Mr. Neill, secretary of legation at Lima, sends under date of October 31, 1900, translation of an article from a local journal regarding the establishment of a national steamship company on the Peruvian coast, which, if successful, is to extend its service as far as Central America and San Francisco. Several projects, he adds, are being discussed by the Lima Chamber of Commerce for the formation of this important enterprise, in order to afford greater facilities to the country's industry and commerce. The article notes the development of other lines of steamers trading on the west coast of America, and quotes the opinion that with 1,200,000 soles ($584,-400) four steamers might be bought for the coasting service between Arica and Guayaquil, with many advantages to home traffic.

Asiatic Export Bureau in St. Petersburg.—Vice-Consul-General Hanauer, of Frankfort, under date of November 18, 1900, sends the following:

On the 1st of January next, a Russian-Asiatic export bureau will be opened at St. Petersburg. Its aim is to facilitate trade with the Far East. This bureau has a capital of 2,000,000 rubles ($1,010,000), and will have branch offices in Warsaw, Moscow, Odessa, Vladivostock, Chabarofsk and Tschita.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

TRADE NOTES AND RECEIPTS.

Ink for Writing on Celluloid is prepared by dissolving a tar-dye-stuff of the desired color in anhydrous acetic acid.—Die Werkstatt.

Kufmerfeld's Washing Fluid is prepared as follows, according to Neueste Erfahrungen und Erfindungen: Rub up 75 grammes of milk of sulphur with 125 grammes of glycerine in a mortar, next add 50 grammes of camphorated spirit and 1 gramme of lavender oil, and finally stir in 250 grammes of rose water and 1 liter of distilled water. The liquid must be stirred constantly when filling it into bottles, since the sulphur settles rapidly and would thus be unevenly distributed. The above quantity gives 12 bottles of 125 grammes each or 25 of 60 grammes.

Perfume for Denaturized Spirit.—The Seifensieder Zeitung, Augsburg, gives the following recipe:

East Indian lemon oil	1250	grammes.
Mirbane oil	1000	"
Cassia oil	50	"
Clove oil	75	"
Lemon oil	100	"
Amyl acetate	500	"
Spirit (95 per cent)	7	kilos.

Dissolve the oils in the spirit and add the amyl acetate. The mixture serves for destroying the bad odor of denaturized spirit in distilling. Use 50 grammes of the perfume per liter of spirit.

To Prevent the Freezing and Sweating of Show-Windows.—I. Dissolve 55 grammes of glycerine in 1 liter of alcohol (63 per cent), to which a little amber-oil is added for scent. As soon as the mixture is limpid, the inside surface of the show window is rubbed with it, using a window chamois or a linen rag, whereby not only the freezing, but also the dimming and sweating of the windows is obviated.

II. To prevent the dimming of eyeglasses, etc., a specialty, called "Oculustro," has latterly appeared, which consists essentially of oleine-potash soap mixed with about 3 per cent of glycerine and a little oil turpentine. Similar mixtures have also been recommended for polishing physicians' reflectors, show-windows, etc., to prevent dimming.—Der Seifenfabrikant.

Process for the Direct Production of Sulphate of Ferric Sesquioxide from Pyrites and Sulphureted Ores, by M. Meurer.—In pyrites and other sulphureted ores the iron is in the state of bisulphide. If this bisulphide is heated with an alkaline polysulphide in a muffle, it is decomposed into magnetic pyrites, free sulphur and ferric monosulphide. The ferric monosulphide thus obtained is in such a state that it can be oxidized with the greater facility.

When the mixture of pyrites or other sulphureted ore and of alkaline polysulphide is removed from the muffle it is allowed to cool in the air, and then washed to eliminate the added salts. The resulting solution is separated from the residue, which is dried and exposed to the air. An oxidation of the ferric monosulphide takes place without any exterior heating, as is necessary in the ordinary roasting of pyrites. On the contrary, the heat engendered within the mass by the oxidation will increase, even to spontaneous combustion. To accelerate the oxidation the chambers in which the mixture treated by the alkaline polysulphide is exposed to the action of the air may be heated; but it is not necessary, and the temperature should not exceed 200 degrees C.

After the spontaneous combustion, the mass is converted into sulphate of ferric sesquioxide, which is lixiviated with water and extracted.—Translated from La Revue des Produits Chimique.

Experiments with Oleic Acid.—(From the German of W. Fahrion, in the Chemiker Zeitung.) Three years ago the writer procured from a prominent house, known for dealing in pure products, a quantity of oleic acid chemically pure. In the meantime, other matters engrossed his attention, and the intended experiments were postponed. The oil, which has remained in a flask closed with a cork stopper, has remained unchanged in appearance. It is still a clear, yellow oil, limpid, and when treated with petroleum ether leaving but a slight residue. Its acid indication is 180.1 (theory 198.6); its iodine indication, 84.4 (theory, 89.7). In neutralizing the oil in alcoholic solution by aqueous decinormal soda, a cloud has been produced, denoting the presence of non-saponifiable substances. By extracting with petroleum ether, washing the extract with dilute alcohol and separating the ether, I have obtained a clear yellow oil completely insoluble in cold alcohol and presenting a neutral reaction.

The oil is slightly volatile at 100 degrees. Heated over the water bath, it constantly loses weight, and the loss does not cease even after twelve hours of heating. This oil cannot proceed from the petroleum ether, this having been purified with the greatest care.

In two trials I find that the oleic oil contains 5.53 and 5.67 per cent of non-saponifiable substances. The iodine indication for the non-saponifiable substances stands between 53.3 and 54.8, while the oleic acid, freed from these substances, has, for the iodine indication, 87.0, and for the acid indication, 200.3. Neutralized with normal aqueous soda, the alcoholic solution of the purified acid remains perfectly limpid.

Having isolated a certain quantity of the non-sponifiable substances, I have ascertained that they do not consist of a single compound, as the clear oil has allowed the deposit, after a certain time, of small white crystals.

The filtered oil has given to analysis the following percentages:

	C.	H.	O.
a.	76.46	12.05	11.49
b.	76.37	11.78	11.15
Theory: $C_{18}H_{34}O_2$	76.60	12.06	11.34

These figures correspond to the composition of oleic acid itself.

Not being able to continue these researches at once, I give to the public the results thus far reached, without pronouncing on the non-saponifiable substances engendered by the oleic acid.

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